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TABLE OF CONTENTS

SAE to Aid Armed Forces	17
Controlling Oil Consumption in Passenger Car Engines—PAUL S. LANE	18
Air Force Plans Mobilization With Aeronautical Industry—BRIG. GEN. ALFRED H. JOHNSON	23
How Sulfur in Gasoline Affects Vehicle Engines—R. E. JEFFREY, J. B. DUCKWORTH, and E. J. GAY	25
Flexible, Narrow Rings Retard Engine Scuffing—HELMUTH G. BRAENDEL	29
A New Engine Coolant—ROY A. HUNDLEY	33
Impediments to Tire Longevity—G. M. SPROWLS	40
Pioneering Diesel Lube Alloys—C. G. A. ROSEN	44
The Case for the Turbojet—WINNETT BOYD	49
More Payload for Same GVW Possible with Truck Turbines—W. M. BROWN	52
Fourth Beecroft Memorial Lecturer Named	55
1949 Horning Memorial Award Announced	55
Thermal Gains Seen As Diesel Edge Over Gasoline Engine—F. GLEN SHOEMAKER	56
Dart Turboprop Design Accents Long-Life Features—R. N. DOREY	60



1950 SAE National Tractor Meeting Reported	66
1950 SAE National Aeronautic Meeting and Aircraft Engineering Display Reported	70
CRC Activity Swings Back to Military Problems	76
By-Law Changes	79
Technical Digests	80
SAE Coming Events	81
About SAE Members	82
Technical Committee Progress	86
SAE Section News	89
SAE at Northrop	91
25 Years Ago	92
SAE Student News	98
News Members Qualified	116
Applications Received	120
Have You Changed Your Address?	125

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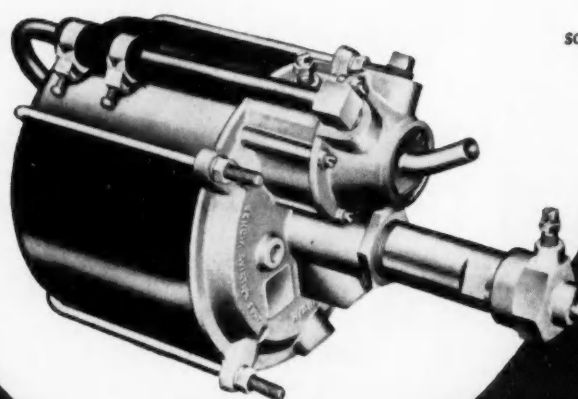
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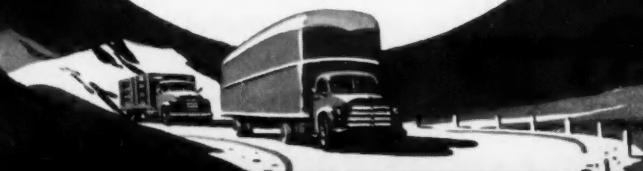
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SAE to REACTIVATE AID To MILITARY

. . . President Zeder
announces



The Society of Automotive Engineers has been called again to assist the U. S. Armed Forces with technical consulting service as it did during World Wars I and II, SAE President James C. Zeder announced today. A recent meeting with top echelons of the armed forces, he revealed, has resulted in subsequent interchanges on specific project possibilities by which SAE shortly will be given new opportunities to provide aid and counsel.

The SAE cooperation, Zeder said, is indicative of the military's determination to utilize in a practical way the great resources of technical mind-power available in American industry. The Army is currently detailing the scope and objectives of a number of specific projects on which it wishes SAE to develop ideas and information for its consideration and use.

"As in earlier crises," Zeder said, "the SAE Technical Board will reach out through all of its contacts in the supply industries and obtain voluntary help from every technical area in the country. The great resources of technical man-power available through SAE once more are going into action in service of the nation."

Controlling Oil Consumption

HOW much oil a passenger car engine consumes depends on a combination of manifold factors. Design of the engine and its components, such as pistons and rings, type of operation, and the oils and fuels used are a few.

What can we consider as normal oil consumption? Here we find a wide divergence of opinion among both engineers and operators. Such factors as size of engine and vehicle are significant. Load, speed, mechanical condition, terrain, environment, maintenance, and others, are all important factors.

The chart in Fig. 1 gives an interesting relationship between fuel economy and oil consumption. The fuel consumed is set down as the measure of work done by the engine or vehicle. For example, idling in the case of a taxicab or low-gear operation in the case of a truck reflects immediately in fuel economy. Similarly speed, load, terrain, and me-

chanical condition of the engine have a potent effect on fuel economy. Recognizing these, we have arbitrarily established oil economy brackets on this chart which then give a relationship of considerable significance.

Today in any American passenger car, when new, the owner can expect to get 600 to 1200 mpq for at least the first 10,000 to 15,000 miles. This figure can be expected to fall off as much as 50% at the end of the next 15,000 mile period. These arbitrary figures will vary, of course, depending on many factors.

Where the Oil Goes

Loss of lubricating oil, whether by leakage or burning, is still "oil consumption." The black trail on our highways attests to the fact that many cars lose oil by leakage. At high speeds, crankcase pressures increase due to blowby. This tends to force oil through main bearing end seals and through the pan gaskets if these are not properly drawn up. External leakage also can occur at the drain plug, front end cover, timing gears, external oil lines, and at valve cover gaskets.

Inside the engine, oil consumption results mainly through burning. It is normally considered the duty of piston rings to keep this loss to a minimum. In more cases than not, the rings are looked upon as the prime offender, though other engine elements may be guilty. Fig. 2 shows the main points for oil loss in a typical passenger car engine.

Excessive oil consumption resulting from burning of the oil within the engine can also come from internal leakage. For example, this can stem from loose connecting rod and main bearings, loose piston pin bushings, and leakage chargeable to the valve assembly. Normally, however, even with the engine in good mechanical condition, burning of the oil introduced along the cylinder walls results in oil consumption.

Let us imagine that we are sitting down with an engine builder or car manufacturer to discuss what we might mutually do to turn out in production an engine with good oil economy performance. What would we ask him to do about the cylinder block?

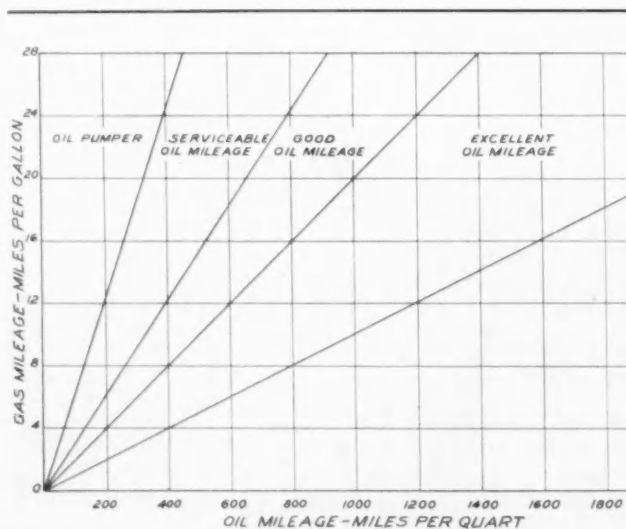


Fig. 1—Relationship between fuel consumption and oil consumption. This chart shows that fuel consumption serves as an indication of the work done by the engine, not always shown by the speedometer

in Passenger Car Engines

EXCERPTS FROM PAPER* BY

Paul S. Lane, Director of Research, Muskegon Piston Ring Co.

* Paper "Oil Consumption in Passenger Car Engines," was presented at Mid-Michigan Division of the SAE Detroit Section, Owosso, May 9, 1950.

First we might make reference to the remarks of A. T. Stahl of Mack Mfg. Corp.:

"Probably the greatest single factor in successful control of oil consumption is the cylinder barrel. When it remains a true cylinder, little difficulty is experienced, but it becomes a real source of trouble, remaining forever a disturbing or destroying factor should it be subject to fixed or variable distortion."

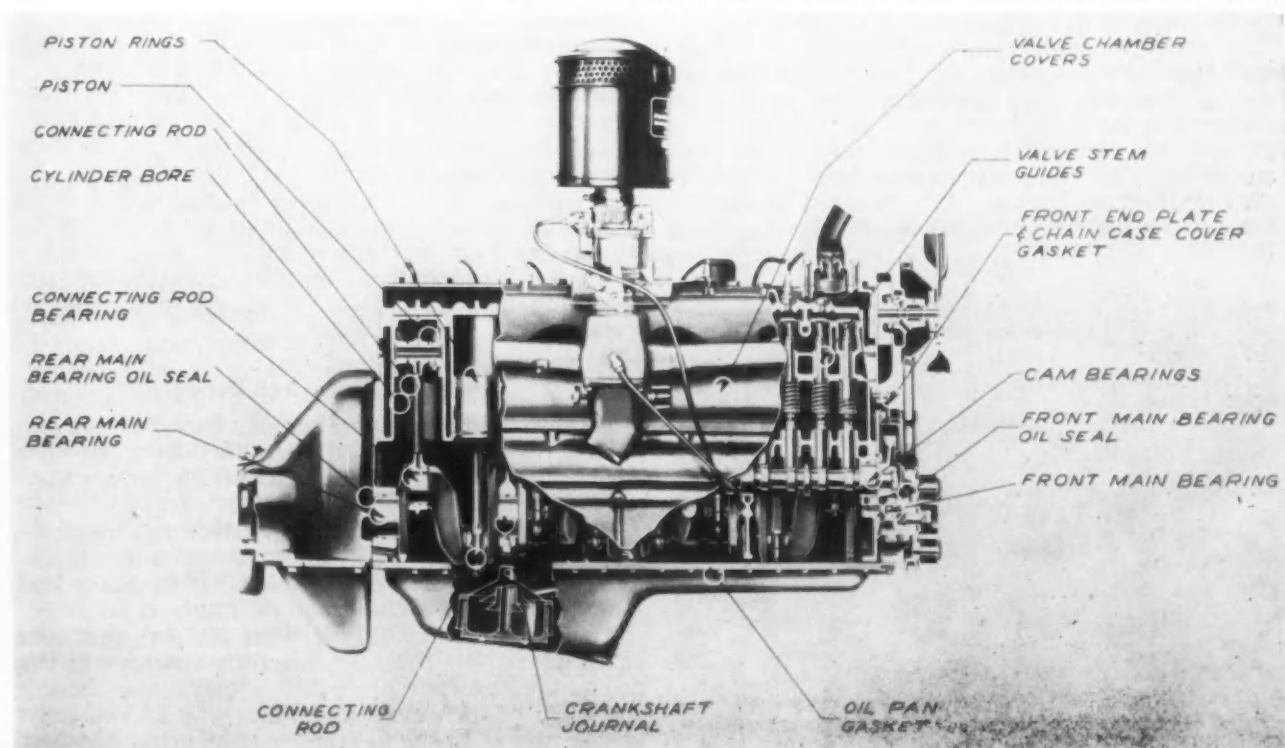
Stahl considers fixed distortion as that due to stud loading, insufficient deck rigidity, or faulty design relation between stud bosses, cylinder bore, and cylinder deck. Under variable distortion of the

cylinders, he refers to the cooling system and combustion chamber design.

Then we would ask about the metallurgy of the block casting, urging that his metallurgical department check and control the resultant metal structure in the bore areas. Without doubt the machine shop must be satisfied as to how the top deck and pan rail grind, cut, and tap. But this must not be the only yardstick of good block iron.

Next we would hope that this particular engine producer has kept up-to-date and is using the very latest methods for machining the bores round to 0.0003 in. rather than to 0.003 in. Also, we would

Fig. 2—Points in passenger car engines at which oil can leak externally and internally



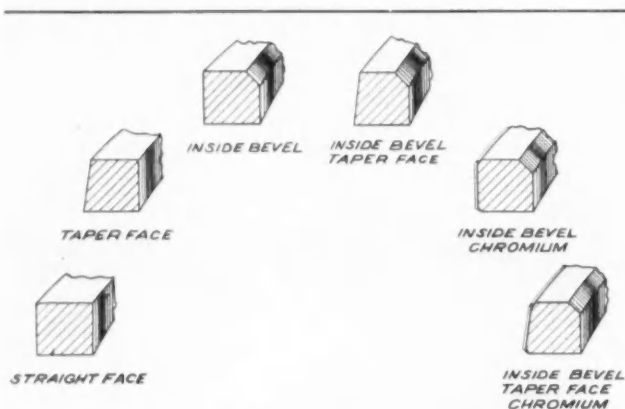


Fig. 3—Compression ring types used in most present-day passenger car engines. Trend is toward more narrow widths of 3/32 in. and under

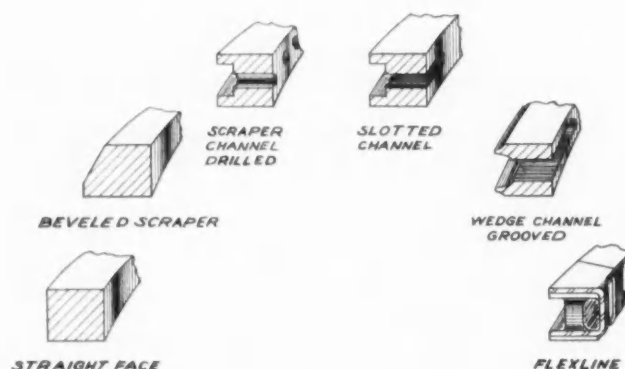


Fig. 4—Evolution of oil control rings. The wedge-channel groove type is most widely used. It has high unit pressure, wide ventilations, and streamlined channel

warn that bore finish can be made too smooth. In fact, glazing and loading of production hones, together with the understandable desire of the hone operator to "develop a nice shine," makes too-smooth bores an every-day hazard.

We would urge that bores be finished by honing to develop a chevron or cross-hatch pattern, using

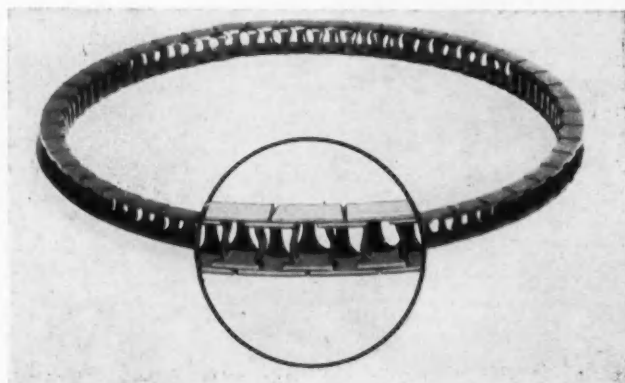


Fig. 5—The Flexline oil ring is a circumferentially compressible, one-piece steel ring. It conforms to all cylinder contours and has exceptional resistance to plugging

as a partial guide, control of micro-inch in the range of 15 to 30 rms. This character of surface finish gives good adjustability to the bores, without excessive metal debris during break-in. This same surface wets readily with oil and aids greatly in bedding in the mutually rubbing surfaces.

We would hope that this engine we are building is one with full-length water jackets, preferably of overhead valve design, to give us better cooling and less likelihood of heat distortion. We'd hope, too, that the cooling passages are always completely cleaned from core sand, and core rods, and that cooling water distribution has been studied and distributed to eliminate "hot spots" and distortion.

Next we might discuss the supply of oil to the valve chamber. It must be ample to provide stem and guide lubrication, but if too copious, we'll have trouble. A mist rather than droplets is desired here. We would urge use of synthetic rubber seals on valve stems, and maybe between the valve guides and block. We would do this because of some recent experience where we observed high oil consumption from leakage at these areas.

Next item up for discussion is the piston, since this too affects oil consumption of our engine. We would hope that selective fits are used, that the ring grooves are carefully machined and checked to be square with the axis. Out-of-square grooves can make any piston rings misbehave. Ovality and skirt taper are important as well as good thermal conductivity, strong ring lands which do not distort under high-speed operation, and ample drainage area through the oil ring grooves. We will both recognize the fact that the piston must close off most of the opening, leaving the final sealing and oil metering to the rings. Then if we could have a chemical coating or plating on the piston, with good groove width control and good pin fitting, all should be fine.

We also would like to know a little about the oil throw-off from con rod bearings or from the splash system. In this country we all favor a copious oil supply to the cylinder walls. This makes for more complete lubrication and better cooling and flushing. Nevertheless, we can get too much, to the point where our rings are overloaded by sheer bulk.

A squirt hole in the top rod bearing cap is often desirable from the standpoint of starting lubrication. But here again, particularly with excessive bearing clearances, the supply can be too abundant. Doubling bearing clearances give a five-time increase in oil supply volume.

Ring Installation and Design

By this time our engine builder friend might say, "We'll try to control all these variables, but how about the rings? What installation precautions should we use?"

We would first talk about "upside-down" compression rings. Taper face compression rings, if inverted, will increase oil consumption by 500% and make a brand new engine an oil pumper.

The first responsibility is with the ring producer to see that these rings are correctly wrapped in the production package or "rolls." Engraving, usually the word "Top," must all be one way in the rolls. In the case of inside beveled or inside counterbored

compression rings, designs of the twist type, correct installation is equally important. (Machining the inside cut, after the rings are chemically treated, aids in identifying the top side.)

Most engine builders now have ring installing fixtures to assemble the rings on the piston without damage to them. This is also true for installing the piston, ring, and rod assembly into the bores. We would warn here, however, that oil ring lands can be injured and in fact rings broken at this operation if the pistons are permitted to drop or fall, causing the bottom oil ring to strike the top of the block.

Finding the right piston ring combination for any given engine still remains far less of a science than is desired. Each ring setup or complement which gives satisfactory performance has, at one time or another, by one person or another, been referred to as a "lucky" combination.

Though present-day engines run longer before overhaul becomes necessary, no one replaces just the piston rings at this time. Instead, much additional labor and other new parts are needed to put the engine into a good rebuilt condition. Pistons, pins, bearings, valves, and cylinders all need refinishing, refitting, or replacement.

Compression rings are important in their effect on oil consumption. Most engines in 1950 passenger cars use one of the following types in top and/or second grooves: taper face, twist type, taper face twist type, and chrome plated twist type. The degree to which these compression rings contribute to oil control varies as to engine and ring setups. See Fig. 3.

Evolution of compression rings as regards width has been from 3/16 in. through 1/8 to 3/32 and 5/64 in., with the thick wall being used in the more narrow widths. The narrow compression rings have the advantage of reduced inertia and flutter, improved resistance to scuffing, and better conformability to bore contours. The narrow compression rings also enable the piston designer to use a smaller width ring belt and heavier lands between the grooves.

Considering for a moment just the top compression ring, we find that some engines have "high top ring sensitivity," others have "low top ring sensitivity" as regards oil consumption. In one series of tests recently made, where only top rings were varied, oil economy ranged from as low as 300 mpq to as high as 1500 mpq. In an engine of another manufacturer, the same changes in top compression rings influenced oil economy only to a small degree.

Second compression rings are also important in oil control, again more so in some engines than in others. They must perform the dual function of supporting the top ring in sealing compression and serving as an auxiliary oil control ring. Another important function of the second compression ring is for it to act as an oil baffle between the ventilated oil ring and the top compression ring. The ventilated oil rings retain considerable oil which by inertia forces and ring movement is thrown upward. If this oil reaches the top compression groove, it will be burned in the combustion chamber. As regards oil control ability in either top or second groove, the taper face and the taper face twist type

appear equal at offering maximum control. The straight face ring is least effective in this respect.

An important detail of compression rings is the character of the face finish. Coarse turned rings, having a thread depth greater than 0.0005 in., adversely affect oil consumption to as much as 25%. This effect continues until the rings wear to more shallow depth or until the threads fill with varnish and carbon. This may require several thousand miles of operation.

Still broader use will be made of chrome plated rings as their merits are better understood and appreciated. Nothing appears to offer "so much for so little" in giving the engine builder promise of longer engine life as a result of reduced wear of cylinders and rings. The chrome ring used in the top groove gives a highly desirable factor of safety against scuffing, which could result in a penalty in economy and durability. Cold scuffing, break-in scuffing, abrasive wear, corrosion wear of rings and bores are all eliminated or greatly reduced when a chrome top ring is used.

Oil control rings have progressed from the plain or straight-face ring to the channel designs having first drilled holes, then narrow slots, then to the present-day wide slot streamlined channel version, generally used in 3/16 in. width. See Fig. 4. An even newer type is the circumferentially compressed steel ring.

Effect of Wider Rings

Cast-iron oil rings 3/16 in. wide, as compared with the more narrow oil rings, have wider slot openings for drainage and resistance to plugging. The added mass also enables these rings to carry higher unit pressure.

With oil rings made to good standards of flatness and pressure contour, the two most important factors affecting oil control ability are (a) unit pressure, and (b) drainage area.

Unit pressure is a function of tension and land width or bearing area and largely determines the oil-scraping ability of the ring. The higher the tension or the smaller the bearing area, the higher

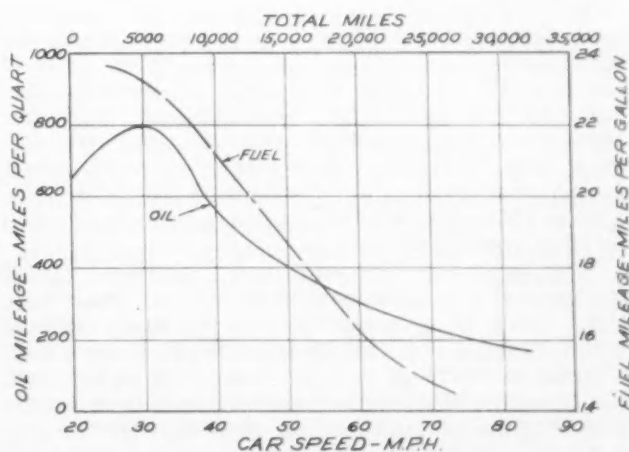


Fig. 6—Higher driving speeds take a toll in oil consumption as well as fuel economy, as this chart shows

the unit pressure. Oil control rings of 10 years ago were made with 0.030-in. lands and 50 psi unit pressure. Today oil control rings have lands as small as 0.004 in., and unit pressure as high as 300 psi. Surprisingly, these very narrow land rings, being adequately lubricated, give excellent life without excessive wear.

Tests made on oil rings without slot ventilations prove the importance of ample drainage area. These slots or ventilations form a passageway through which oil scraped from the cylinders is returned through the piston into the crankcase. It is important that they do this rapidly to enable them to receive a clean, fresh supply on each succeeding stroke.

From the standpoint of maintaining oil control over long mileage, the slots are equally important. Their width largely determines plugging resistance, and the degree of plugging has a direct effect on oil consumption. The change to oil ring widths of 3/16 in. in most passenger car engines permits slot widths of up to 0.075 in.

Considerable interest centers at this time on steel oil rings of the flexible type, formed from steel strip and obtaining their tension by circumferential compression.

A new ring of this type, named the "Flexline," is shown in Fig. 5. Features of this ring include complete side sealing of the openings between the segments forming the lands proper, together with compressibility up to 0.500 in., giving the design a low spring rate. This means that this design loses tension more slowly with ring wear. This ring design also provides unusually good resistance to plugging.

Speed Consumes Oil

For a given vehicle, oil consumption increases rapidly with increase in speed. The number of round trips of the pistons and rings are the same per mile, whether at 25 or 75 mph. However, at the higher speed heat is "piled up" into pistons and cylinders, oil gets hotter, thinning out and getting past the rings more readily. Also, the vital cooling function of the oil is largely lost. At higher speeds, more oil is thrown on the bores, with less time for it to drain back through the oil rings to the crankcase.

As the crankcase temperatures rise, oils are vaporized with resultant higher losses. At certain speeds, different in different engines, the rings lose some of their ability to follow unstable bore contours. Result—further loss of oil accompanied by higher blowby with its disastrous abuse to the entire engine. Fig. 6 illustrates the penalty we must expect to pay in increased oil consumption at higher road speeds. Similarly fuel economy is adversely affected by high speed driving.

It is generally accepted that lubricating oil of higher viscosity gives somewhat lower oil consumption. This is particularly true of worn engines where bearing and ring clearances are excessive as a result of wear. It has also been pointed out that the heavier oils of higher viscosity result in excessive bearing temperatures in new or newly rebuilt engines. Wear and oxidation rates are lower with oils of higher viscosity.

Many factors must be weighed in deciding on optimum viscosity for any specific application.

Heavier oils increase starting friction in cold weather; oils too light give insufficient protection on rubbing surfaces in warmer operation. For general passenger car operation, SAE 10 or SAE 20 grades are mostly used. For high mileage drivers or fleets the premium type heavy-duty blends are most economical.

Several car manufacturers have carried out some recent work with break-in oils. Initial economy is greatly improved for as much as 2000 miles with an added factor of safety against break-in scuffing.

Compression Ratio

Higher compression ratios put an added burden on the lubricating oil, particularly on its function as an important cooling medium. Higher pressures and temperatures mean more heat flowing into cylinder walls and pistons, with added heat transfer through the rods to crankcase. Increased temperatures in crankcase, particularly with engines of small capacity, can reflect in higher oil consumption.

In newly designed engines of higher compression ratios, full length water jackets, more rigid block construction, and ample crankcase capacity and oil flow, offset any oil consumption penalty. In engines originally designed for lower compression ratios, there may be a hazard of reduced structural rigidity, more chance for distortion, and the possibility of greater oil usage because of the inability of the rings to seal effectively under such conditions.

The degree to which existing oil economy in a given engine is affected by an increase in compression ratio will depend on the particular ring combination in use. The effect is generally in the direction of greater oil consumption, particularly if the existing ring complement is "borderline."

Type and grade of fuel used have an important effect on oil consumption. Combustion chamber deposits cause a sizeable loss in power, sometimes accompanied by pre-ignition as well as detonation. Both of these result in piston ring and engine damage, soon reflected in higher oil usage.

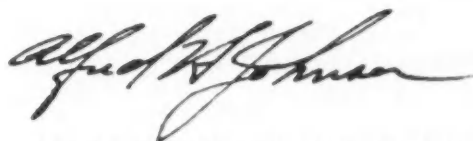
Low grade or "dirty" gasolines, particularly when used with unsuitable lubricating oils, result in sludging and varnish deposits. In as little as 5000 miles, these engine deposits can completely plug oil ring drainage openings, stick compression rings, and make the engine an "oil pumper."

It is now generally believed that passenger car engine deposits, under the usual conditions of driving, come from the fuel rather than oil oxidation. One reason for this condition is the high power-weight ratio demanded in our present-day vehicles for acceptable performance. Secondly, the average passenger car operates on a schedule with considerable idling, light loads, and stop-and-go operation on short trips. This means that in most designs the engines are running too cool, under which conditions water and fuel condensation takes place. There is a need for more education in the direction of using higher temperature thermostats so that the jacket temperatures are 160 to 180 F and oil temperatures are in the same range.

(Paper on which this abridgement is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

The current aeronautical industry is the backbone of Air Force planning. Upon the industry's competent management we must depend for continued advice and counsel on the ways and means to carry out our planning. Only by having a strong, going aeronautical industry will we have any springboard from which to jump, if mobilization is necessary. The assistance our current industry can give us depends on the current business they have.

Many members of SAE have individually contributed their time and effort to assist the Air Force in its plans. The group as a whole has always expressed a willingness to cooperate. I appeal to you now to offer assistance and suggestions in any field of our industrial planning which you think appropriate.



Brig.-Gen., USAF, Chief, Industrial Planning Division

Air Force Plans Mobilization With Aeronautical Industry

EXCERPTS FROM PAPER* BY

Brig.-Gen. Alfred H. Johnson

Chief, Industrial Planning Division, Air Materiel Command, U. S. Air Force

* Paper "Industrial Mobilization Planning with the Aircraft Industry," was presented at SAE National Aeronautic Meeting, Los Angeles, Sept. 30, 1950.

AIR Force industrial planning starts at the very top of our Government. Our plans stem from national policy and the decisions of the Joint Chiefs of Staff. From the national policies and the decisions of the Joint Chiefs of Staff, detailed requirements for military equipment to support our combat forces are developed. Ultimately, fairly detailed major end item schedules are developed and plans are initiated aimed at the utilization of the Air Force's allotted portion of the national resources to produce the items required. Our national resources are in themselves limited and it quickly develops that in many cases the resources made available for the aircraft portion of the program must be compromised for other essential requirements and will not be sufficient to meet what the Air Force needs. This is a healthy situation. We realize that every national resource must be used to its utmost efficiency in event of mobilization if we are to win a war.

The Air Force is planning the utilization of five of our major resources—we call them the five M's—management, manpower, machines, materials, and money.

The resource management, includes the organiza-

tions which management runs. The Munitions Board, in its Industry Allocations Program, has set up a system in which the resource *Management* is allocated between the Air Force, Army, and Navy. The Air Force plans under this Industry Allocation Program with the management of that segment of American industry allocated to us.

Plans are drawn with the management of our current aircraft or aeronautical industry to pass on their know-how, engineering advice, and techniques to the managements of other portions of American industry which will be required to support our national effort and produce aeronautical equipment in time of emergency. Licensing arrangements are worked out not only between various segments of the current industry, but between segments of our aeronautical industry and those of the automotive and other large industrial organizations.

For example, an aircraft developed by the management of the Boeing Aircraft Co. has been selected as the type meeting a mobilization requirement. Other aircraft companies or managements are selected to run additional plants manufacturing aircraft to the Boeing design. Almost every aircraft company cur-

rently producing aircraft is voluntarily planning with the Air Force for the future production of aircraft currently designed and being produced by a competitor.

In addition, to meet mobilization requirements, licensing agreements have been made between current aeronautical producers with the managements of the automotive industry and other large industrial segments to manage and build specified aeronautical equipment. The recently completed agreement between Ford and United Aircraft is an example.

There are definite limitations as to the detail with which this type of planning can be carried out. We cannot tell every segment of industry in detail what we want them to build and when we want it because as we go down through the prime, sub, and sub-subcontractors, we will reach a point in planning of "no return" due to the dynamic qualities of our basic requirements themselves.

Manpower

The Air Force quickly realized that manpower was a field for planning where a great amount of effort should be placed. In any mobilization program, manpower will require the closest of attention. Working with the Aircraft Industries Association, which has cooperated to the utmost, the Air Force has developed a manpower plan with details and procedures aimed toward the elimination or minimization of the numerous major deficiencies which existed during the last war.

The Aircraft Industries Association played a most important part in working up the details of this plan. The plan, as completed, was submitted to Headquarters in Washington, where it was studied, submitted to the Munitions Board for further review and is currently being reviewed by the Munitions Board, the National Security Resources Board, and other agencies responsible for promulgating our national manpower plan in time of emergency. It is safe to predict that any manpower program and procedures, which are promulgated in event of emergency, will incorporate a good proportion of the procedures recommended jointly by the Aircraft Industries Association and the Air Force.

In addition to this broad overall manpower plan, the Air Force realizes there will always be a general manpower deficiency in time of emergency. With this in mind, the Air Force has entered into numerous manufacturing methods studies aimed at simplifying manufacturing and reducing the manhours per item required. The items selected for manufacturing methods and producibility studies have been those on which the Aircraft Industries Association has indicated the broadest field of usage and where we can expect the most pronounced results—Lockheed's integrally-stiffened aircraft skin projects, Republic's tooling projects, and Curtiss-Wright's steel extrusion projects are examples. All these projects are aimed at both reducing costs in money and manhours and advantages will be gained in both current and mobilization production.

Machines

Machine tools and related production equipment, a most important resource insofar as aeronautical production is concerned, is receiving our closest

attention. Even in our current expanded program the pinch on machine tool deliveries to meet production schedules is tight. Builders are quoting longer and longer delivery dates. Although a good deal of this tightness is due to the current level of normal civilian economy, it is indicative of what we can expect in time of emergency.

Working with our prime contractors in the aircraft industry and with their licensees in what will be the aircraft industry in time of emergency, the Air Force is building up information on requirements to meet our needed production. Along with similar information from the other Services, information for pool orders is fed into the National Resources Board.

As you know, the Air Force, along with the other Services, maintains a machine tool reserve. These tools are stored in two former aircraft plants under good storage conditions. These tools, of course, are of World War II vintage and in varied stages of immediate usefulness. Many must be repaired before being placed in use and of course there are numbers of them which are practically new.

The Air Force is currently engaged in a minimum processing of these machine tools aimed at avoiding to a maximum any further deterioration. Actual repair or replacement of parts on these tools will depend on future limitations of funds made available for this purpose. We have in the past utilized these storage tools to augment the production facilities of our current aircraft industry and, with the current program, there will be additional withdrawals of machine tools from reserve to meet the vital requirements of our current production schedules.

We are now in the process of working out the details of allocating this machine tool reserve to the various plants which will require the tools in event of mobilization.

Materials

The Air Force has two major planning fields in regard to materials. One is for the method of controls to be used in the distribution of what materials are made available. In general, members of aeronautical industry have expressed the need, even in our current program, for the institution of a central aeronautical group similar to the Aircraft Scheduling Unit of World War II to handle the materials allocation program. It is anticipated that in event of mobilization, plans similar to the controlled materials plan for World War II will be effected.

The second covers making the materials that will be made available to the aeronautical program go as far as possible. This second problem breaks down into several categories—one is conservation, including reduction in scrap, controlled scrap handling, and re-engineering to reduce the materials required in high volume production.

Another is substitution. Working with the aeronautical industry we have initiated numerous projects, aimed at the substitution of magnesium and plastics for aluminum and the utilization of titanium in lieu of steel or aluminum.

Another major field is the complete redesign of jet aeronautical engines to reduce to a minimum

Continued on Page 39

How Sulfur in Gasoline Affects Vehicle Engines

EXCERPTS FROM PAPER* BY

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* Paper "Effects of Sulfur in Motor Gasoline on Engine Operation," was presented at SAE Summer Meeting, French Lick, Ind., June 6, 1950. This paper will be printed in full in SAE Quarterly Transactions.

A CRC field test of 62 vehicles showed that the influence of high gasoline sulfur content may vary from a pronounced effect on cylinder and ring wear, at some operating conditions, to no effect under continuous operating conditions at normal engine operating temperatures. To a considerable extent, this increased wear does not check general field-service experience, even in areas where high-sulfur gasolines have been widely used.

The 62 vehicles completed field service tests at seven test sites during the period of October 1947 to June 1949. (See data on test vehicles, type operation, and sites on bottom of this and the following three pages.) Two motor gasoline sulfur levels of 0.056 to 0.140% and 0.25 to 0.30% were compared with regard to engine wear and cleanliness. A total of 1,501,698 miles was accumulated in service, rang-

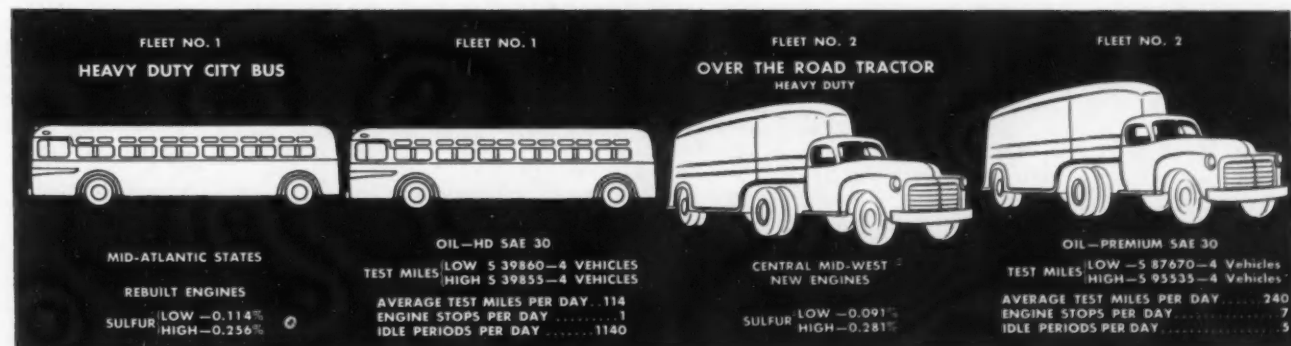
ing from light duty to intermittent duty to continuous heavy duty. From these tests the following results emerged:

Results in Heavy-Duty Service

Twenty three vehicles in three fleets—representing four engine types used in heavy-duty or moderate-duty continuous service, such as over-the-road trucks, urban bus service, or medium bus service—showed essentially no difference in wear for gasoline sulfur content within the prescribed limits. This is shown in Fig. 1. No intercity bus-service test was conducted; but based on the results of the over-the-road truck service, it may be reasonable to assume that the same result would apply.

Thirty four vehicles in four fleets produced con-

Vehicles Tested



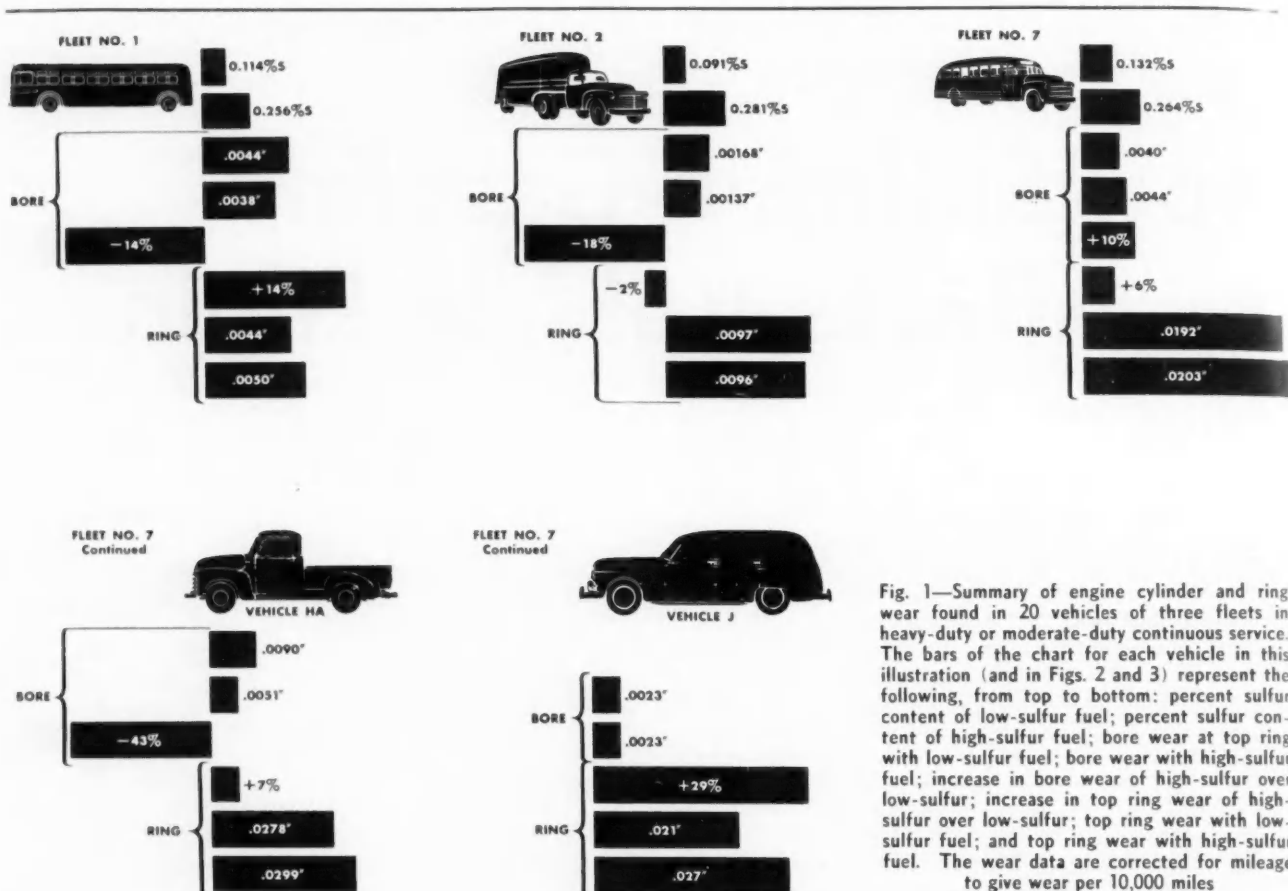


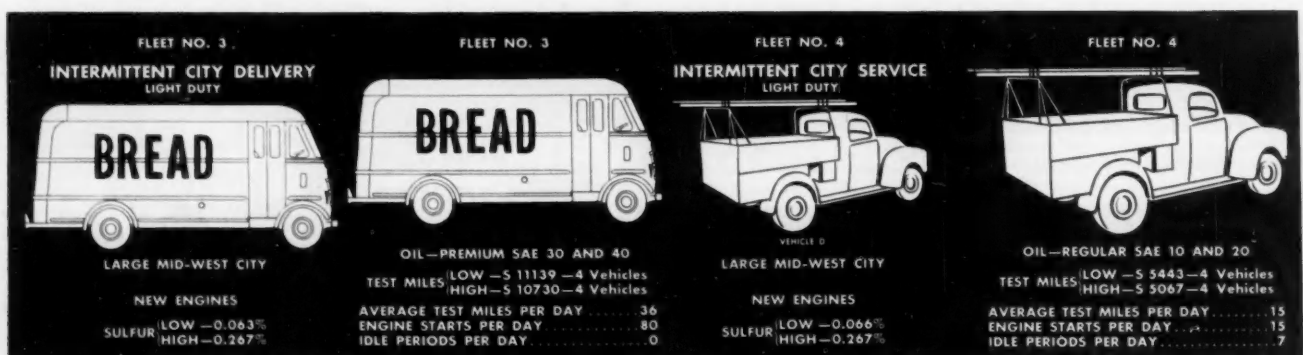
Fig. 1—Summary of engine cylinder and ring wear found in 20 vehicles of three fleets in heavy-duty or moderate-duty continuous service. The bars of the chart for each vehicle in this illustration (and in Figs. 2 and 3) represent the following, from top to bottom: percent sulfur content of low-sulfur fuel; percent sulfur content of high-sulfur fuel; bore wear at top ring with low-sulfur fuel; bore wear with high-sulfur fuel; increase in bore wear of high-sulfur over low-sulfur; increase in top ring wear of high-sulfur over low-sulfur; top ring wear with low-sulfur fuel; and top ring wear with high-sulfur fuel. The wear data are corrected for mileage to give wear per 10,000 miles

sistent differences in wear within the prescribed sulfur limits, as shown in Fig. 2. These vehicles represented five engine types, in light-duty intermittent service, with many stops and starts or idle periods per day. Typical services for these vehicles are city delivery routes, such as bread and parcel delivery, light repair or trouble shooter trucks for gas, telephone, and electric utilities, supervisors' cars, and so forth.

Eight vehicles in one fleet—engaged in typical medium-duty intermittent delivery service, door-to-door—showed a marked increase in wear. In this fleet, the low-sulfur fuel used was 0.056% and the high-sulfur fuel 0.269%; a regular grade oil was used. Wear for the high-sulfur engines had progressed to a level requiring an overhaul. See Fig. 3.

Use of heavy-duty crankcase oil (REO-37) in this fleet produced a 50% reduction in cylinder wear in

Vehicles Tested



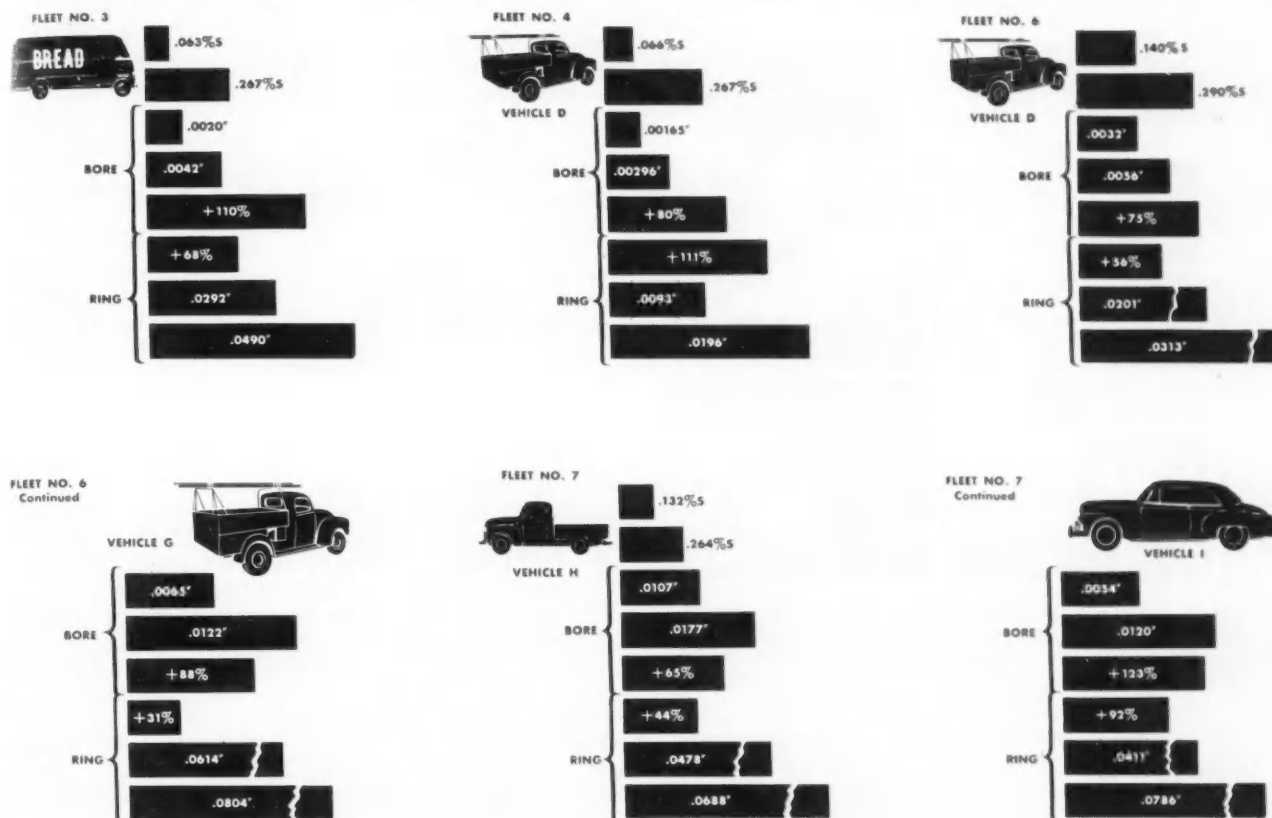


Fig. 2—Engine wear data found in engines of 34 vehicles in four fleets in light-duty intermittent service. These vehicles operated on delivery routes and in public utility operations, with much stop-and-go driving and many idle periods

vehicles operated on the low-sulfur fuel, but did not appreciably reduce cylinder wear in the high-sulfur vehicles. Cylinder wear for both oils and the high-sulfur fuel was 0.005 to 0.006 in. However, when using the (REO-29) regular oil and the low-sulfur fuel, wear was 0.003 in. With the low-sulfur fuel and the (REO-37) heavy-duty oil, the wear was about 0.0015 in., or about one-half the amount of wear obtained with the regular oil.

In this same fleet, No. 5, a heavy-duty oil (REO-37) was compared with a regular oil (REO-29). It was noted that both crankcase and oil-ring groove deposits were reduced for both high and low-sulfur vehicles by the heavy-duty oil.

In comparison of a West Coast fleet, using a naturally-occurring high-sulfur gasoline, against another fleet in a midwest city using the same vehicles in the same type of service and using gaso-

Vehicles Tested



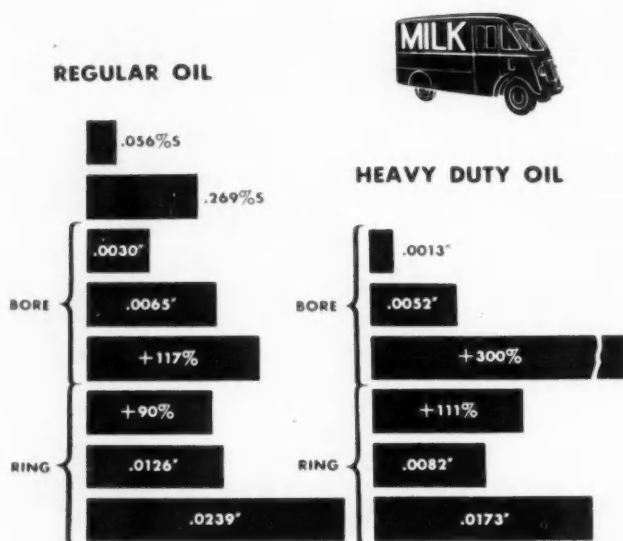


Fig. 3—High-sulfur fuel greatly increased engine wear in the eight vehicles of Fleet No. 5, engaged in door-to-door delivery service. Tests also showed that heavy-duty oil more than halved bore wear with low-sulfur fuels, but brought no appreciable wear reduction with high-sulfur fuels

line with disulfide oil added, wear results were substantially equivalent. This confirms previous tests made during the laboratory test phase.

Valve operation and valve life were not adversely affected by high-sulfur fuel. Three low-sulfur vehicles in one heavy-duty fleet were overhauled during the test period because of sticking valves.

Muffler life and exhaust system corrosion were not adversely affected by high-sulfur fuel. In all but one of the seven fleets there was little or no effect of high sulfur on engine varnish and sludge deposits. This other fleet showed differences of 7 to 10 points (out of a possible 100) in favor of the low-sulfur fuel.

The tests also seemed to show that neither ambient air temperatures nor geographic location make a difference in engine wear between high and low-

sulfur fuels. This was based on two fleets in light-duty intermittent service, and within the range of atmospheric conditions and temperatures prevailing during the test period. (The actual mean minimum air temperatures were 18 and 45 F.)

The test data do not permit separation of the effect of engine design on the difference in wear due to sulfur because of the influence of service type. In fleet No. 6, using two vehicle types, percentage increases in wear with high-sulfur fuel were not significantly different. But the absolute rate of wear in one vehicle type was about twice as high as that in the other with both high and low-sulfur fuels. Maximum difference in bore wear was 0.0016 in., and the test mileage was 2900 and 3400. (Compare charts for Vehicles D and G of fleet No. 6 in Fig. 2.)

Correlation with Lab Tests

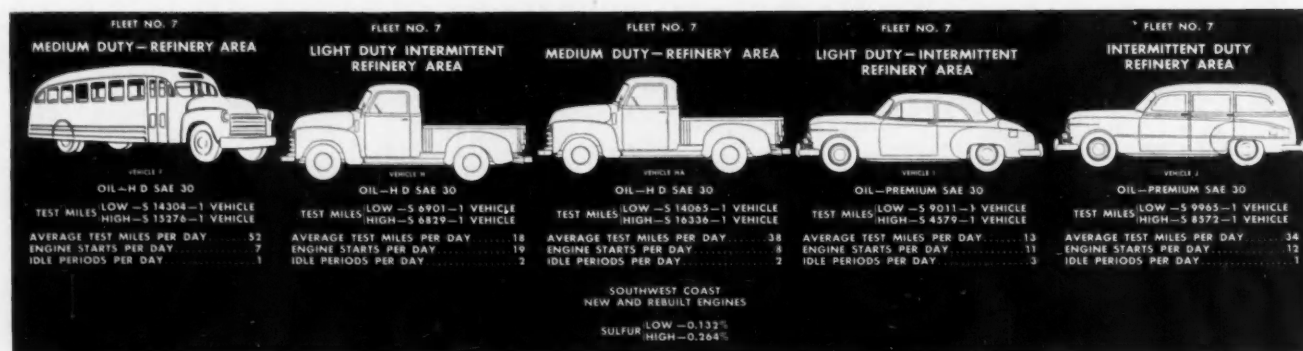
The program also showed that laboratory dynamometer FL-2 tests qualitatively reflect the effects of high sulfur on cylinder and ring wear in light-duty intermittent service; but L-4 tests do not reflect wear in medium to heavy-duty service.

The program of determining the effect of sulfur in gasoline on engine operation was initiated in September, 1945. Laboratory engine tests preceded the field tests to (1) indicate the conditions, and (2) aid in selection of fuels for field service tests. Some 100 engine tests covering at least 3800 test hours were compiled and analyzed.

In addition to conducting the field service tests in this country, CRC cooperated with the National Research Laboratories of Canada on this problem. From 1946 to 1948 service tests were made at the Canadian Army Proving Ground using military vehicles. Operation under stop-and-go driving conditions produced no significant difference between fuels containing approximately 0.05 and 0.30% sulfur. The cylinder-bore wear observed in the Canadian tests, however, did not exceed 0.001 in. after 2300 miles on either low or high-sulfur gasoline.

Paper on which this abridgement is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers. The CRC report on the program, "Sulfur in Motor Gasoline, January 1950," also is available from SAE. Price: \$3.00 to members, \$6.00 to nonmembers.)

Vehicles Tested



Flexible, Narrow Rings Retard Engine Scuffing

BASED ON PAPER* BY

Helmuth G. Braendel, Chief Engineer, Wilkening Mfg. Co.

* Paper "Design Features Affecting Wear," was presented at SAE Summer Meeting, French Lick, Ind., June 6, 1950.

CONFORMABLE oil rings and narrow compression rings will hold down scuffing brought on by inevitable cylinder distortion.

Scuffing stems from the inability of oil rings to provide a uniform oil film for lubricating compression rings during all operating conditions. If the rings operated in straight and round cylinders, this would be easy. A properly designed cylinder will remain straight and round, and provide uniform cooling along the entire stroke length during all operating loads.

Only design which could conceivably meet these requirements is a full-floating wet sleeve. It would be free from any thermal or structural deformation. But such design is too costly for passenger cars or even medium size trucks.

So, we have cylinders that do not remain straight nor round. And unless piston rings are designed to

meet these unfavorable conditions, heavy wear and short life will be the penalty.

Main way to overcome effect of high spots and localized dry areas in distorted cylinders is to make the oil rings exceptionally conformable. The ring should be designed to exert a uniform pressure against the cylinder wall, regardless of wall shape or change of shape, as the ring moves along the stroke. Result will be a uniform oil film metered to the compression rings and virtual elimination of conditions for scuffing.

Additionally, oil consumption also will decrease with the paradoxical result that engines running exceptionally dry will also show unusually low wear when disassembled. This means that the ideal in minimum uniform oil metering has been achieved. There is just enough to lubricate the compression rings sufficiently under all operating conditions.

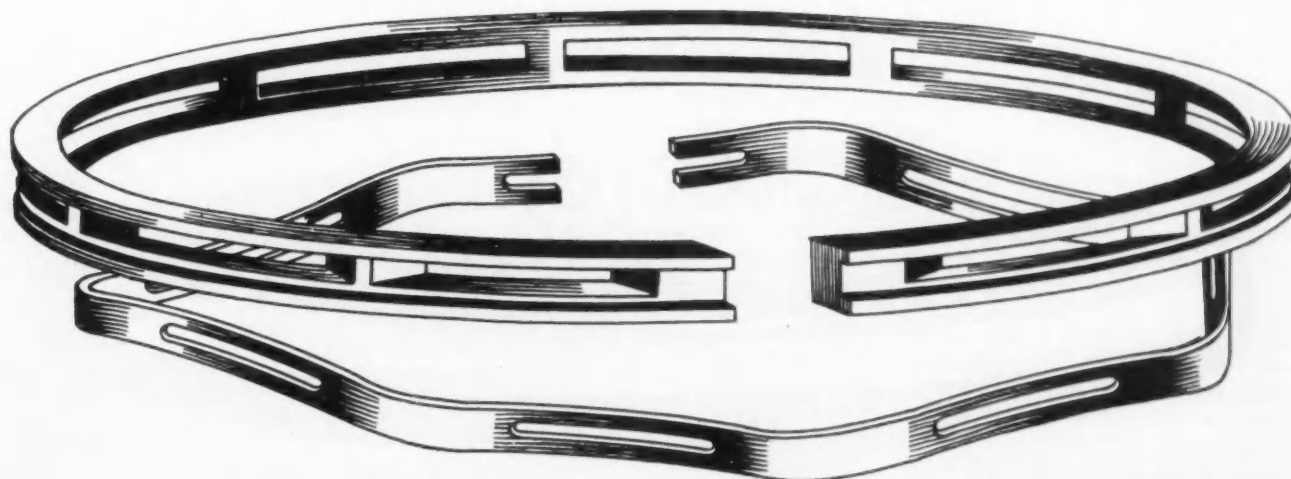


Fig. 1—Conformable oil ring using conventional hump-type expander

Relatively conformable oil rings have been available for years. Such rings are less thick radially to make them flexible. They also have some auxiliary loading device to give them sufficient wall pressure. Expanders contact the bottom of the groove and the ID of the rings to provide the supplementary radial pressure required.

Engine builders have been unreasonably prejudiced against using such conformable rings, largely, I suspect, because the engine designer doesn't want to admit he has enough cylinder distortion to warrant more than the plain snap ring.

Recently improvement was made by providing flexible rings with auxiliary radial pressure. This is done with an inner ring which simultaneously exerts uniform pressure on the ring around its entire circumference, but does not contact the groove bottom. The conventional groove-bottoming and hump type expander exerts its force on the ring at eight or nine points. It is very dependent on accurate groove depth to provide proper radial force. The new equalizer is designed on the peripheral abutment principle. It is entirely independent of groove depth, provided sufficient space is available; but this is the case in any standard SAE groove.

Fig. 1 shows the conventional expander. The new peripheral abutment expander, in Fig. 2, can be used with any type conformable ring. In this case the equalizer is shown with a very conformable steel ring, with chrome plated faces, in production for several truck and bus engines.

Such conformable rings bring amazing results. When one manufacturer first placed these rings in production, his dynamometer tests showed oil consumptions improved 500 to 1000%. He then conducted a large-scale field test.

Bus Fleet Accrues Benefits

A fleet of buses, which had been equipped with two conventional type single-piece oil rings per piston, gave between 40 and 60 miles per quart. The single-piece rings were replaced with the ring shown in Fig. 2. After installing these Cromflex

rings, oil consumption dropped from 40 to 60 miles per quart to 600 to 900 miles per quart. The test was made on five engines.

The engine displaced almost 700 cu in. Because the engine was used in city bus operation, which was very severe, I feared the cylinder assembly would be too dry. I induced the company to pull down the two driest units and replace the Cromflex at the bottom of the skirt with the conventional ring. Oil consumption promptly fell to between 200 to 500 miles per quart.

The test was conducted under controlled conditions until the five units had accumulated between 43,000 and 50,000 miles each. During this period there was very slight depreciation in oil control. We obtained an almost horizontal oil control characteristic.

Unfortunately, the company was so satisfied that it found it unnecessary to retain an engineer on this job. Thus, we were not able to determine when the engines were pulled down and to get wear measurements. But I feel that wear from scuffing would be negligible in this operation. Recently, several large manufacturers have equipped their engines with conformable rings and derived better cylinder wall lubrication with lower oil consumption.

Compression ring design also bears importantly on scuffing resistance. For the past 30 years compression rings have become progressively narrower as specific engine output has increased. Narrow rings became necessary for two reasons, both aimed at scuffing reduction. First, a narrow ring tends to scuff less than a wide one. Second, because of mass effect, narrow rings prevent scuffing from blowby.

Let us analyze the force and pressure relationships of a narrow and wide ring for the same bore engine, operating at the same combustion pressure. We will find that the wide ring operates with a face pressure far above that of the narrow ring. Fig. 3 shows the forces acting on both the narrow and wide rings. Both rings have the same radial thickness.

For the ring to seal blowby, there must be enough

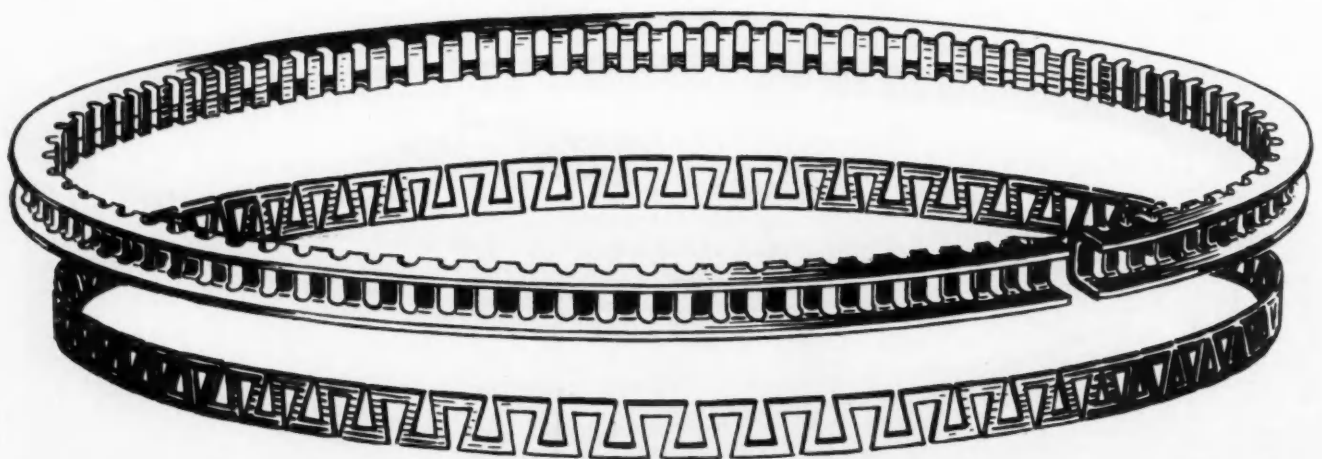


Fig. 2—The Cromflex ring with peripheral abutment equalizer represents an advance in flexible oil ring design. This expander exerts uniform pressure around the ring's entire circumference, instead of at eight or nine points, as with the hump-type expander in Fig. 1

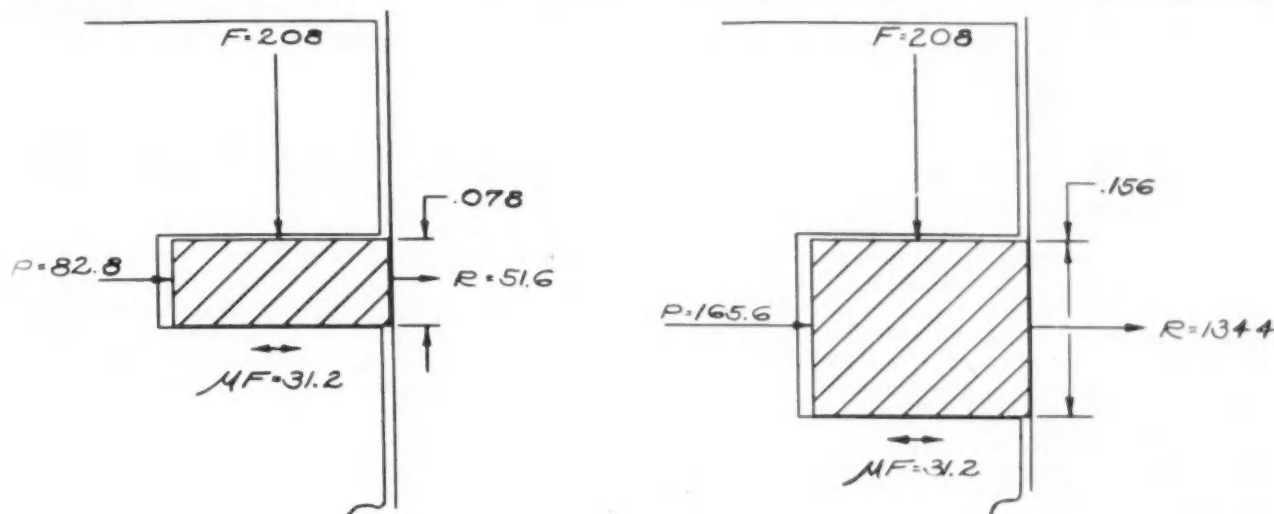


Fig. 3—Forces due to gas pressure are twice as great on the 5/32-in. ring at right are greater than those on the 5/64-in. ring at left. This is why wider rings are more conducive to ring scuffing than narrow ones

side clearance to permit compression pressures to act freely on both top surface and back of ring. The ring must make an effective seal with the cylinder wall along its face, and with the bottom side of the piston groove to control gas passage.

Force acting downward is combustion pressure times ring side area. This force is the same for both the narrow and wide rings. But force acting on the back of the ring equals combustion pressure times ring width area. In this case, comparing 5/64-in. and 5/32-in. compression rings, it will be twice as high for the latter as for the former.

This force is modified by the frictional force, consisting of μ , the coefficient of friction, times F , the downward force. This is constant for both ring widths. Resultant force on the cylinder wall then will be $P \pm \mu F$ for the narrow ring and $2P \pm \mu F$ for the wide ring.

Ratio of nominal pressures due to these forces would not account for the big difference in scuffing resistance life found in actual engine tests between these two rings. But we may again find the answer in conformability of the two rings with the cylinder wall. In this case we are concerned with axial conformability. Since no cylinders are perfectly straight, the narrow ring will conform at any particular time with a much greater proportion of its area to the cylinder wall than the wide ring.

In fact, actual area in contact of both rings may be the same at any one time. It is possible that the contacting area of the narrow ring is often quantitatively greater. Thus the actual pressure with which the ring contacts the cylinder wall at any one instant is probably very closely proportional to the resultant outward force.

Forces Calculated

To show this more clearly, let us assume a combustion pressure of 1000 psi, a cylinder diameter of

3 3/4 in., and friction coefficient of 0.15. Numerical results with these assumed conditions are computed as follows:

- (1) $F = p(D - T)\pi T = 1000(3.75 - 0.185)\pi(0.185) = 208 \text{ lb}$
- (2) $P_{.078} = p(D - 2T)\pi W = 1000(3.75 - 0.370)\pi(0.078) = 82.8 \text{ lb}$
- (3) $P_{.156} = p(D - 2T)\pi W = 1000(3.75 - 0.370)\pi(0.156) = 165.6 \text{ lb}$
- (4) $\mu F = 0.15(208) = 31.2 \text{ lb}$
- (5) $R_{.078} = 82.8 \pm 31.2 = 114.0 \text{ to } 51.6 \text{ lb}$
- (6) $R_{.156} = 165.6 \pm 31.2 = 196.8 \text{ to } 134.4 \text{ lb}$
- (7) Ratio of forces of wide to narrow rings = $\frac{196.8}{114.0} \text{ to } \frac{134.4}{51.6} = 1.7 \text{ to } 2.6$

where:

D = Bore diameter = 3.75 in.

μ = Coefficient of friction = 0.15

p = Gas pressure = 1000 psi

T = Radial thickness = 0.185 in.

W = Axial width 0.078 in. for narrow ring and 0.156 in. for wide ring.

Suppose we assume the actual contacting areas of the two rings are the same (and I don't believe we are far from the truth in this assumption). Then in anything but a very straight cylinder we would have a face pressure ratio of the two rings of 1.7 to 1 or 2.6 to 1, depending on whether the friction force between ring and groove is acting with or against ring back pressure.

This difference in actual pressures accounts for the narrow ring's scuffing and scoring resistance on the upper part of the stroke, where the ring is subjected to very high gas pressure. During the first part of the combustion stroke, real ring face pressure becomes so high with a wide ring that lubricant is squeezed out at the low relative sliding velocity. This induces scuffing and produces heavy wear during the upper part of the stroke.

Second advantage of narrow rings over wide ones

is a mass effect. This is of practical importance in all automotive engines during high operating speeds. P. de K. Dykes thoroughly investigated this effect, and reported it in "Piston Ring Movement During Blowby in High-Speed Petrol Engine," published by the Institution of Mechanical Engineers.

Aim of this investigation was to determine the precipitous rise in blowby which occurs in every engine at some engine speed, unless this critical speed is above the operating range. Sensitive electrical contacts were installed into the bottom and top sides of the groove and across the ring gaps. Sequence of ring motions could be closely observed during the engine cycle and correlated with blowby break-off point. This is what was found:

Up to the point at which blowby rose extremely fast, gas pressure acting on the ring top was sufficient to hold it pressed down against the groove bottom. This simultaneously permitted the same pressure to act on the ring back to keep the face in contact with the cylinder wall. As soon as the blowby break-off point was reached, the electrical contact imbedded in the grooves indicated ring movement from the bottom toward the top of the groove. This occurred at a point just before top dead center. In other words, ring momentum was sufficient in approaching top dead center to overcome effect of gas pressure holding it down.

When this happened, pressure on the ring back was spilled downward and the ring depended only on its own inherent tension to make contact with the cylinder wall. Combustion took place just after the ring moved away from the groove bottom and just before top dead center. Rapid gas pressure rise of the presently unloaded ring collapsed the ring, allowing gases to rush past the face.

At first the investigator believed the spilling of gas volume, acting on the ring back, to be responsible for the increased blowby. But this increase was so large that the displaced gas could not account

for the quantities passed. Evidence of butting ends at disassembly induced the investigator to install contacts to determine definitely the sequence of ring collapsing action.

The blowby break-off point could be varied by changing engine throttle. At part loads or lower combustion pressures, engine speed at break-off was actually much lower than at wide-open throttle. It is easily seen that gas pressure holding the rings down was lower at part throttle. Thus ring momentum overcame gas pressure earlier or at a lower engine speed.

This study points up the need for narrow rings in high-speed automotive engines to move the blowby break-off point beyond the operating range. If this is not done, resultant blowby will bring scuffing due to physical removal and burning of the oil film by the high velocity gas stream passing the rings. Prolonged operation in this range will also break the rings.

Other design features on rings, pistons, and cylinders will reduce scuffing and parts wear. Cylinder finish, antiscuff coatings on compression rings, chrome-plated rings, and oil control features on pistons are a few.

Considering such detailed design features in building the piston, ring, and cylinder power assembly will yield extremely low wear rates, with good performance over a long life under heavy-duty operation. The designer can use these means at very little sacrifice in original cost. If we increase specific engine outputs, we will be compelled to take advantage of these features to maintain present engine wear rates, even if first cost considerations prevent us from exploiting them fully in present-day engines.

(Paper on which this article is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

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A NEW Engine Coolant

EXCERPTS FROM PAPER* BY

Roy A. Hundley Chief, Automotive Group, Hodges Research and Development Co.

* Paper "A New Concept in Internal Combustion Engine Cooling," was presented at SAE Southern California Section, April 27, 1950.

ORSIL, a synthetic liquid, looks attractive as an engine coolant because it remains a liquid under all temperature conditions in engine cooling. Its heat transfer properties, lower than that of water, yield performance and service advantages not possible with existing cooling systems or media, or by any reasonable engine modification. Among them are waste heat suppression, ability to burn leaner mixtures, faster warm-up rate, and slower cool-down rate.

This liquid is one of a family of organic silicate compounds known generically as Orsil. Outstanding properties of these compounds are high boiling point and very low freezing point. The member of the family selected as the Global Coolant has a pour point of -101 F, is pumpable at -70 F, and boils at 680 to 700 F. It retains its liquid phase throughout this temperature range at atmospheric pressure. As a coolant, it will not freeze or boil.

It is inert toward metals and materials in the cooling system, and has no limitations with respect to foaming, odor, or toxicity. It is stable and does not evaporate. It has an acceptable coefficient of expansion, high flash and fire points, is a nonelectrolyte, and is compatible with crankcase lubricants. It is not miscible with water and is used at 100% strength.

Orsil, being a synthetic liquid, does not have heat transfer properties as good as water. Evaluation of the overall heat transfer characteristics of any liquid is difficult, and authorities differ as to the most acceptable basis for evaluation. Best value on relative properties can be given by our own test work in the laboratory. We found that, for equal coolant flow rates, in a given engine, with a given heat transfer system (fan and radiator), at equal heat input (speed and load), and without a thermostat, Orsil will reach an equilibrium temperature 35 to 40 F higher than water.

Metal temperatures in the head on the combustion chamber side and metal temperatures in the bore will reach equilibrium temperatures, under the same conditions as above, approximately 120 F higher with

Orsil than with water. These higher metal temperatures give rise to new conditions of engine operation which necessitate changes. The higher metal temperatures encountered naturally bring about a complete new vista of engine operation.

Barring accidental loss of coolant, the liquid will remain in the cooling system for years without further attention or concern, regardless of whether the vehicle is on the Alcan Highway or on the desert. Because of its inertness toward the metals and materials in the cooling system, the cleanliness and "newness" in the jackets and radiator will always be retained. There no longer will be scaling and rusting conditions. From these standpoints, Orsil is "ideal" as a coolant.

Cooling Characteristics

But what happens in actual operation? How will the liquid perform as a coolant? What sort of metal temperature patterns will be encountered when using Orsil as compared to water? How effective is this liquid in critical areas?

To answer these questions, some 50 or more thermocouples were installed in an engine of a popular lower price bracket car. The engine was selected because of its Siamese bore design, in which three pairs of cylinders are tied together without coolant passages between them. This presents as severe a cooling condition as was believed possible

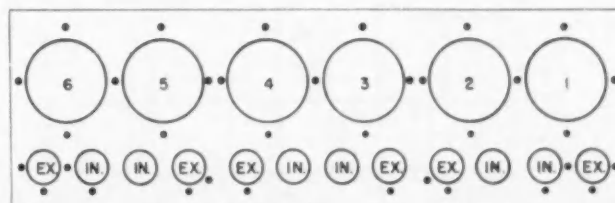


Fig. 1—Location of thermocouples on top deck of cylinder block in testing Orsil as an engine coolant

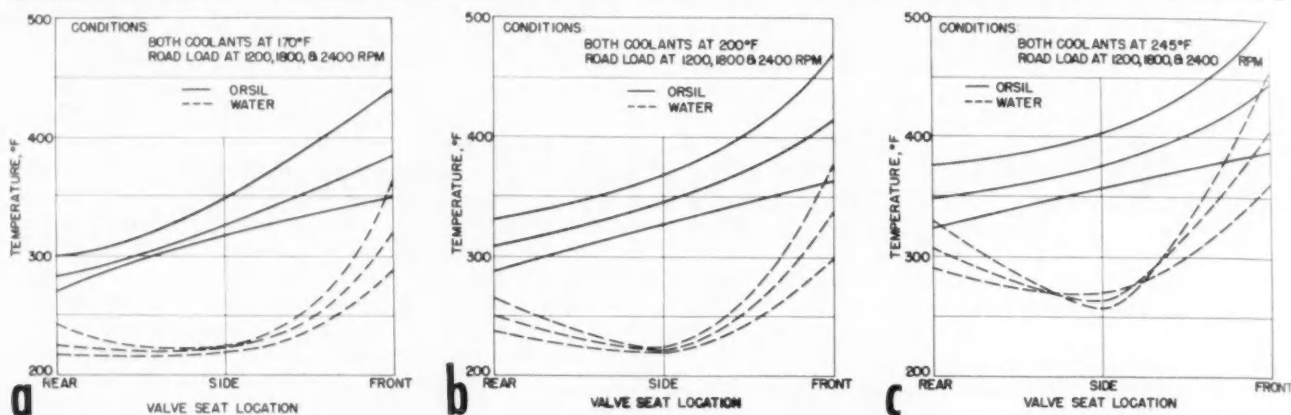


Fig. 2—These charts show the temperature pattern around the No. 6 exhaust valve. The chart in (a) gives results with both coolants at 170 F; (b) at 200 F; and (c) at 245 F

to encounter. Some 10,000 temperature readings were taken throughout the test program. Fig. 1 shows the location of the many thermocouples in the top deck of the cylinder block.

Figs. 2 a, b, and c show metal temperatures around No. 6 exhaust valve seat at coolant temperatures of 170, 200, and 245 F at road load from 1200 to 2400 rpm, the temperatures rising with rpm. The 245 F coolant temperature test with water was, of course, conducted under pressure. All Orsil tests were conducted with an open system.

Exhaust valve life is directly a function of its temperature. The greatest portion of heat removed from the standard exhaust valve (differentiating from sodium cooled) is achieved by the quality of its contact on its seat and the duration of such contact. Unequal temperatures around the valve

seat cause distortion and reduce the quality of contact. These tests have demonstrated that a non-boiling liquid can reduce valve seat distortion by reduction of temperature differences in adjacent portions of the circumference of the valve seat.

The point just forward of No. 5 exhaust valve and between two exhaust valves gave rather consistently the highest metal temperatures encountered. Fig. 3 shows metal temperatures at this point. The temperatures have been plotted against coolant out temperature for road load conditions from 1200 to 2400 rpm. The two readings at 220 F with water are based on an open system and a sealed system.

In addition to the evidence of far greater uniformity of temperatures with Orsil, there is also shown the complete breakdown of cooling ability of water in the boiling range. In this same vicinity the temperature differences between the point illustrated in Fig. 3 and an adjacent point 90 deg around No. 5 exhaust valve have been studied and plotted in Fig. 4.

These curves show what are believed to be indications of the difficulties encountered when water boils locally, even when controlled out-temperature is below atmospheric boiling point and even when under pressure at temperatures above 212 F. There is some evidence of decrease in metal temperatures at increased water temperatures in the boiling range. This is caused by ebullition with resulting high heat transfer rates; but such conditions of heat absorption can only exist when rate of heat flow is low.

Higher heat flow, brought about by higher speeds on the road load curve and/or higher throttle settings, rejects heat faster than the steam formed locally can be replaced by water. Resulting heat transfer to steam (a gas) rather than water is many times less. This brings about the greater temperatures and temperature differences. Temperatures, although higher, are more uniform when using a liquid which will remain in liquid phase, even under the most severe conditions or the highest rates of heat flow.

In other tests it has been noted that when using water, regardless of the controlled temperature of the water, the cooling system performs increasingly

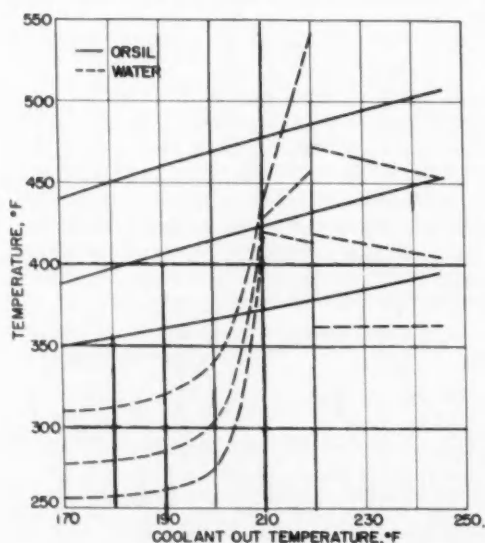


Fig. 3—Metal temperatures forward of No. 5 exhaust valve at 1200, 1800, and 2400 rpm road load

better as the pressure in the system is raised above the steam table pressure for the particular temperature encountered. This "supercharging" of the cooling system decreases the size of the steam bubbles formed. It provides for rapid and effective replacement of these steam bubbles by the liquid water.

The source of such pressures for "supercharging" is not readily obvious nor would the pressure be easily controlled. It is also well-known that, when at or near a boiling point, there may be a condition of steam flashing in the suction of the coolant pump, drastically reducing the flow rate. The necessity for keeping the coolant in its liquid state is extremely important to be assured of high temperature protection, but the necessity of relying on pressure to retain this liquid state presents a condition which is not considered reliable.

The temperatures at the point between bores Nos. 3 and 4 have been plotted in Fig. 5. The characteristic pattern noted on curves illustrating valve seat temperatures is retained in Fig. 5. All points within the engine generally follow such form. The higher but uniform temperatures with Orsil are characteristic and the rather rapid increase, particularly in the boiling range with water, is retained throughout as a typical condition.

These data show that a liquid—even though having a heat transfer coefficient less than water, but one that is always a liquid under all conditions of operation—can satisfactorily perform the function of cooling. It will improve the cooling in critical areas by reducing temperature differences.

Effect on Octane Need

Heat basically aggravates octane requirement. From this theoretical consideration only, one would hesitate to accept a condition where metal temperatures around the combustion chamber are increased an additional 100 F. Such considerations, however, should not be accepted dogmatically. A study and analysis of the problem is warranted.

It is a fair statement to point out first that the octane requirement when the engine is new is not the problem faced by the petroleum industry. Rather, it is the on-the-road requirement after several thousand miles of operation. The increase in octant requirement comes mainly from combustion chamber deposits. The increase can come from hot spots created by scaling in the jackets. Octane requirement increase can come from hotter exhaust valves as poorer seating develops from distorted valve seats. There are undoubtedly many others in this very complicated, controversial subject of octane requirement.

Basic dynamometer work was done on one engine and from this the curve on Fig. 6 was developed. This engine showed a four-number increase for the 40 F temperature difference, indicated earlier as the equilibrium temperature increase that can be expected when full capacity of the cooling system is used under equal conditions of engine speed and load.

Before developing data on what the on-the-road requirements may be, it appears in order to determine the relative requirements when new. Several passenger cars were road tested using blends of iso-octane and n-heptane, checking knock fade-out

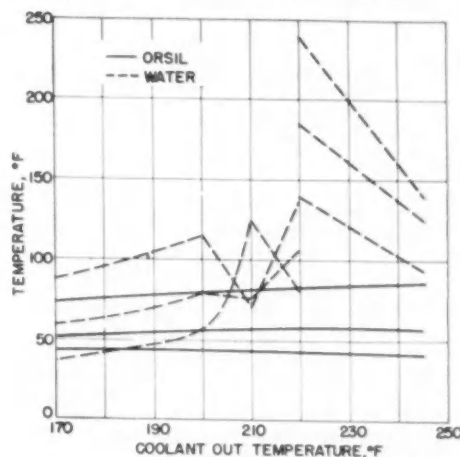


Fig. 4—Differences in temperature between points for which readings are given in Fig. 3 and points 90 deg apart at No. 5 exhaust valve at 1200, 1800, and 2400 rpm road load

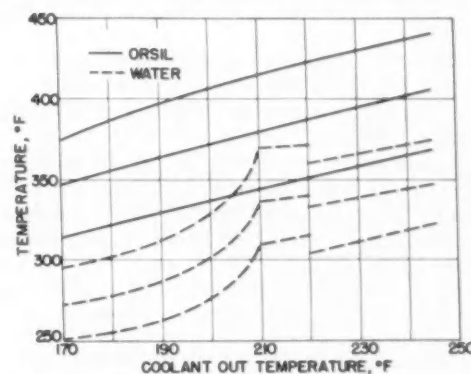


Fig. 5—Metal temperature of cylinder block top between cylinder Nos. 3 and 4 at 1200, 1800, and 2400 rpm road load

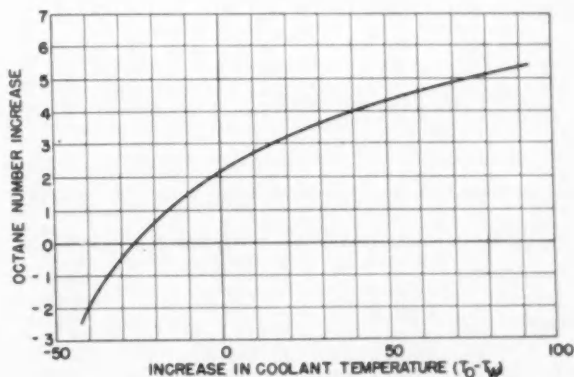


Fig. 6—This chart shows how the difference in coolant temperature between Orsil and water influences octane requirements. Orsil, which operates at a higher temperature than water, increases octane requirement

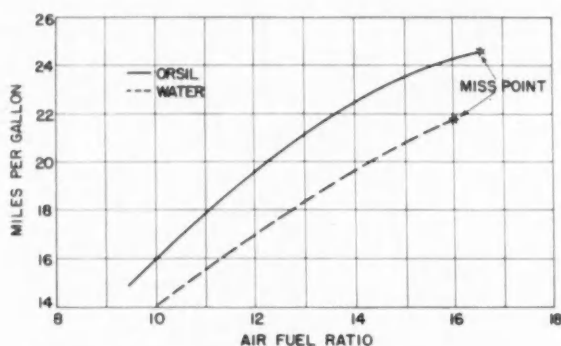


Fig. 7—Ability to burn leaner mixtures with Orsil yields more miles per gallon, as this chart shows. These data on miss point determination are for a 6-cyl, $3\frac{1}{4} \times 4\frac{5}{8}$ -in. engine. The Orsil was at 210 F and the water at 170 F, with operation at 30 mph road load

points as the vehicle is accelerated from 10 to 60 mph on level road. Table 1 gives results of several cars tested.

All vehicles received a very careful carbon cleaning job, but no other alterations or adjustments were made.

We can now consider that new engine requirement for higher temperature operation is four numbers greater than for present standard. But what about combustion chamber build-up?

The same vehicles shown in Table 1 were rated first on water just as received from their owners. They were also rated on water after careful combustion chamber deposit removal. The results are as shown on Table 2.

¹ See SAE Quarterly Transactions, Vol. 3, No. 4, October, 1949, pp. 557-570: "Factors Affecting Octane-Number Requirement," by Harold J. Gibson.

Table 1—Octane Requirement for Clean Engine

Vehicle	C. R.	Octane Requirement Water	Octane Requirement Orsil	Increase
C	6.41	68	74	6
D	6.60	73	75	2
E	6.60	69	73	4
F	7.25	65	67	2
G	7.25	75	77	2

Table 2—Octane Requirement with Water Cooling

Vehicle	Miles of Build-up	C. R.	Octane Requirement Dirty	Octane Requirement Clean	Octane Increase	Grams of Deposits	Grams per cu in. of vol
C	30,347	6.41	83	68	15		
D	12,213	6.60	89	73	16	64.9	1.67
E	5,271	6.60	81	69	12	59.9	1.55
F	4,336	7.25	83	65	18	124.7	2.25
G	7,156	7.25	86	75	11	87.0	1.79

Build-up on the vehicles caused octane increases of 11 to 18 numbers, which correlates well with the work done by H. J. Gibson.¹ Gibson noted that on-the-road cars have a maximum of 28 numbers increase from build-up and an average of 9.4 numbers.

Several of the vehicles used in the above work are back in the hands of the owners and mileage is being accumulated in the same manner as before, but with Orsil as the coolant. At the time this was written, none of the vehicles had accumulated sufficient mileage to determine effect of build-up when operating at the higher temperatures.

Dynamometer work was done, however, to determine the effect of build-up. A popular 6-cyl, L-head engine was subjected to continuous operation using premium fuel at 2000 rpm road load for approximately 3000 miles. When subjecting an engine to such steady load, the conditions are most conducive to formation of combustion chamber deposits. Tests were conducted both with water at 170 F and Orsil at 210 F. In each case following the test period the engine was rated dirty, cleaned, and rated clean again within an 8-hr period of the same day. Efforts were made to minimize influence of temperature, relative humidity, and barometric pressure.

Octane Up, Deposits Down

The results showed that there was a 10-number increase with Orsil wherein 40 g of deposits were removed, and a 22-number increase with water wherein 79 g of deposits were removed.

Present reference data indicate that higher temperatures bring about a reduction of combustion chamber deposits. Supporting evidence is found in an aircraft engine builder's bulletin released about a year ago. It advises users of this company's engines to increase cylinder head temperatures from 400 to 450 F to reduce combustion chamber deposits.

Results of laboratory, road, and reference data indicate that the petroleum industry, faced with meeting the on-the-road requirements, will not be severely affected by Orsil cooling and may even be relieved. As of this writing, the story is considered incomplete and inconclusive. The final result can best be determined after equal build-up time has been accumulated by the test cars now operating on Orsil. Suffice to say, there are many influences on octane requirement already encountered, as pointed out by Gibson, which far exceed the two to four numbers brought about by the use of this synthetic coolant and its resulting higher temperatures.

When discussing fuel economy in passenger cars

we are concerned primarily with part-throttle operation. Full throttle is used so seldom that relatively large changes in the fuel rate at full throttle would have little overall influence on the net change in miles per gallon. The key to fuel economy lies in how lean a mixture can be burned without missing. An increase in mixture temperature results in a condition that is conducive to permitting leaner mixtures to burn.

Laboratory tests were conducted to determine the miss-point under varying temperatures and coolant conditions, and with control of both spark and air-fuel ratio on a dynamometer mounted engine. The data presented in Fig. 7 indicate the potential savings that accrue from being able to burn leaner mixtures.

Considering part-throttle operation further, there is another basic reason for economy gains by use of this synthetic coolant. It has already been pointed out that the liquid is not as good a heat transfer agent as water. As such, it acts as a heat barrier, so that the heat which normally flows to the coolant is suppressed. Heat energy therefore is retained within the combustion gases to produce more work.

Complete thermodynamic studies have been made correlating laboratory heat rejection data with theoretical analyses. It has been shown that at part throttle, a gain in the order of 10% in fuel economy can be realized by suppression of heat to the coolant alone. The following highlights results of these studies.

Laboratory tests on heat rejection work showed that under equal speed and load settings the synthetic liquid absorbed only 80% of the quantity of heat absorbed by water. This is a 20% reduction in waste heat to the coolant. This laboratory result was confirmed qualitatively in road test work by recording lower underhood temperatures when cooling with Orsil.

Authorities in the studies of the theoretical cycle point out that, although approximately one-third of the total energy of the fuel goes to the coolant as waste heat, only 7 to 9% of the total heat energy of the fuel would be available to do useful work, in addition to what is now utilized, if *all* of the heat to the coolant were suppressed. This is because of the limited time period in the cycle during which a saving in the waste heat could be utilized and converted to useful work.

If, then, a maximum of 8% could be realized from 100% heat suppression, it is reasonable to expect 1.6% additional energy to be made available for the 20% suppression recorded by test.

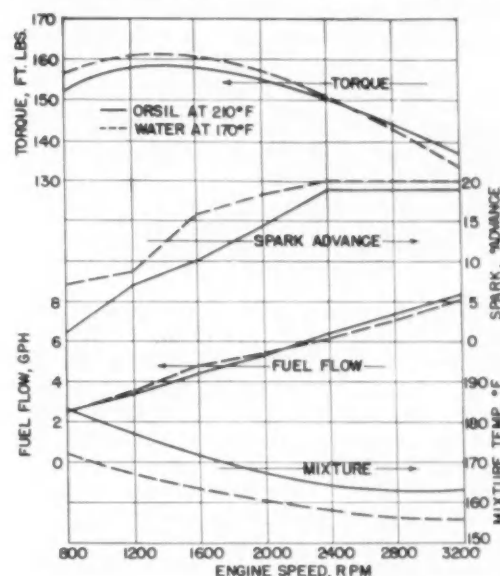


Fig. 8—Performance curves for full-throttle operation with optimum spark and air-fuel ratio

The average automobile engine is approximately 16% thermally efficient at part-throttle road load.

It has then been demonstrated that the 1.6% gain from increased utilization of the heat energy of the fuel results in a 10% gain in thermal efficiency, which is directly recorded in increased tank mileage.

Fuel economies determined experimentally are explained and substantiated theoretically. Together they demonstrate that fuel savings are thermodynamically available, both through the

Table 3—Performance on Orsil Relative to Water in Percent*

Vehicle	Warm-up Time	Power	Maximum Economy	Average Economy	Cool-down Time
C	55	-1.6	16.4	13.1	101
D	57	+1.4	10.9	7.8	142
E	53	0	3.5	1.7	135
F	100	-3.5	17.2	7.6	128
G	66	-1.5	6.8	4.2	150
Average	66	-1.0	11.0	6.9	131

* Corresponding water performance at unity or 100%.

Table 4—Temperatures (in deg F) of Orsil Operation Relative to Water*

Vehicle	Coolant Temp.	Oil Temp. at 20 mph	Oil Temp. at 60 mph	Under-hood	Spark Plug at 20 mph	Spark Plug at 60 mph	Battery
C	+35	+30	+40	-5	+40	+90	
D	+8	+13	+20	-5	+50	+90	-5
E	+14	+28	+30	-2	+30	+65	0
F	+15	+12	+34	0	+42	+50	-2
G	+17	+28	+38	-5	+57	+60	-7
Average	+18	+22	+32	-3	+44	+71	-3

* Temperatures are all Orsil temperatures minus water temperatures.

ability to burn leaner mixtures and by suppression of waste heat to the coolant.

Spark Timing

Before discussing the influence of Orsil cooling on maximum output of an engine, it is advantageous to review the characteristics of spark advance. A prime requirement for maximum output is that the peak pressure occurs at the optimum time. Fundamentally, it is of little significance where the spark occurs.

The point of spark timing is selected so that the delay and the rate of burning characteristics of the combustible charge will produce maximum pressure at the desired time. The rate of burning of the combustible charge is a function of its temperature at the time of ignition. Hotter charges burn more rapidly. Less advance, then, can be anticipated when cooling the engine with Orsil. This lesser advance is not to be confused with usual power loss encountered by spark retard.

Spark advance requirements were determined by dynamometer tests on a conventional 6-cyl, L-head engine by setting in at wide open throttle and adjusting spark and air-fuel ratio for maximum torque. The fuel was regular grade. At no time was detonation severity allowed to exceed borderline intensity. Of particular interest are the last three points from 2000 rpm and up shown in Fig. 8. In getting maximum torque at these higher speeds, detonation was not a limiting condition in the engine when cooled by either water or Orsil. The important variable is temperature. Four degrees less advance was required with Orsil at 2000 rpm and one degree at 2400 and 2800 rpm.

Maximum Output

As with octane requirement, heat fundamentally has an adverse effect on maximum output. All references in the literature point to an average of 2 to 5% loss to be expected. The loss is due primarily to a reduction of charge density. Also, similar to the octane problem, many of the solutions to power loss

apply as well toward octane support.

An engine of popular 6-cyl size was set up with variable timing and fine control of fuel flow rate by application of vacuum to the carburetor bowl. The engine was set at wide-open throttle, and at each test speed the maximum torque was obtained at borderline knock at best spark timing and best fuel flow rate. The results have been illustrated in Fig. 8.

Mixture temperatures were measured on the three intake manifold legs adjacent to the ports in the cylinder block. The hot spot setting was locked and constant for all runs. These mixture temperatures were approximately 10 F hotter when Orsil was the coolant, but it was determined that when mixture temperatures were cooled 20 F the higher torque values obtained with water cooling could be reached.

There has not yet been an opportunity to investigate influences affecting combustion phenomenon at the higher temperatures; but it is believed that the greater torque achieved at the higher rpm when cooling with Orsil is due largely to reduction of friction losses.

The foregoing problems are recognized and an approach to their solution is understood. Power loss is recognized. It is problematical whether the magnitude developed by experiment would ever be noticed by the driver. It is evident, however, that if no loss in power can be tolerated, the easiest expedient is to take air from outside rather than from under the hood. Further solution may lie in a complete investigation of antidetonant injection. Such an investigation is now being made which encompasses, in addition to performance and economy of operation of the engine per se, the complete economic study of actual operating conditions.

Thus it can be said that power loss as a factor in maximum output is not of great magnitude and its restoration is within the grasp of immediate knowledge.

Other Adjustments

Although valve timing changes are beyond the flexibility of our laboratory equipment, their influence deserves consideration. The only control, however, within our capacity is valve clearance. Valve clearances have been set to obtain maximum vacuum at idle. It has been found that intake valves require from 0 to 0.002 in. greater clearance, and the exhaust valves from 0.004 to 0.006 in. greater clearance. All data previously discussed have been taken with valves adjusted under both methods of cooling to obtain maximum vacuum at idle, irrespective of manufacturers' recommendations.

By use of spark-plug gasket thermocouples, the operating temperature at the gasket was found to be from 40 to 65 F higher when cooling with Orsil. Based on this information, all tests with Orsil cooling have been conducted with one grade colder spark plug. As is true of several other phases of the overall study, it is believed that optimum selection and design of plugs represent an unexplored region worthy of attention.

Car Road Tests

The vehicles discussed under the subject of octane requirement were instrumented to determine several pertinent temperatures, acceleration time, and fuel

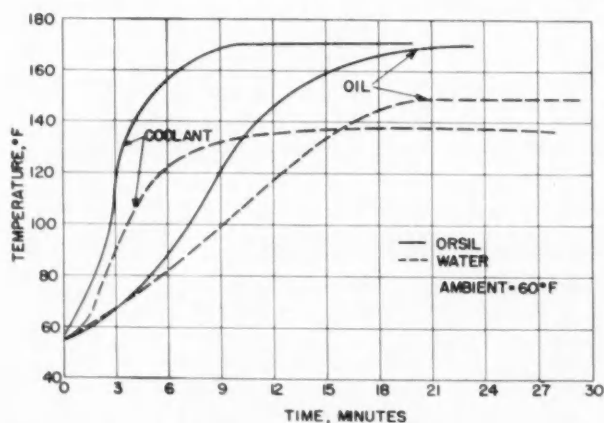


Fig. 9—Because an engine warms up faster with Orsil as a coolant than with water, as these curves show, less corrosive wear due to cold operation can be expected. These warm-up curves are for level road operation at 30 mph

economy under test conditions identical except for the coolant. The results relative to water performance have been accumulated on Tables 3 and 4. Test speed range was from 10 to 60 mph. These vehicles being the personal property of employees, it was not deemed advisable to make the many alterations known to develop improved performance. These data, then, are based on no changes in timing, spark plugs, valve clearances, carburetor jets, or heat applied to the mixture.

The coolant temperatures were measured in the same location as used for the dash board indicator. Oil temperature was measured at the sump end of the dip stick, spark-plug temperatures at the gasket on the aftermost cylinder, and underhood temperature at the top of the air cleaner.

Warm-up was based on time required for the oil to reach 140 F. Power was determined by recording time by stop watch to accelerate at full throttle, level road, from 10 to 60 mph. Cars with Hydramatic transmissions were tested from 20 to 60 mph with third gear kick-down linkage disconnected. Maximum economy is the gain in tank mileage at the point of greatest gain. Average economy is based on the average for the test speed range. Cool-down, as with warm-up was based on time required for the oil to cool down to 140 F.

Engine Wear

The literature is abundant in its coverage of the highly accelerated wear brought about by cold starts and cold operation. It is corrosive wear that is encountered during cold starts and cold operation. The corrosion comes about by the products of combustion combining with the condensation on cold cylinder walls. As pointed out by Cattaneo and Starkman, the complete absence of condensation will not necessarily eliminate corrosion, but its presence greatly aggravates the condition.

A fast rate of warm-up is important to obtain wall temperatures above the dew point of the products of combustion as quickly as possible. Temperatures of the engines in vehicles tested have not been taken on the metal walls, but data on rate of warm-up of coolant and oil have been taken by use of the strip chart recorder on road vehicles discussed above. Fig. 9 shows a characteristic pattern for warm-up of coolant and oil.

Alex Taub has pointed out the influence of carburetion on wear rates. He shows that during normal part-throttle operation a difference between a 12 to 1 and a 14 to 1 mixture ratio may affect bore wear three to seven times. Under-oiled engines of course are more severely affected by mixture ratio. The reason given by Taub is that it is believed that the oil film is weakened by dilution.

Not only then is the ability to burn leaner mixtures because of higher operating temperatures advantageous for fuel economy, but it can well be expected to contribute to reduced wear.

During a cold start the mixture ratio is approximately 1 to 1 and during warm-up may be 8 or 9 to 1. If a wear ratio of 3 to 7 to 1 is noted on an engine by a mixture ratio difference between 12 to 1 and 14 to 1, the order of magnitude for wear during warm-up from destruction of the oil film can be recognized.

The faster warm-up rates with Orsil as the coolant

are derived because of its lower heat transfer properties. Cool-down rates are inversely proportional. The evils of sludging lube oil from cold operation are known, and protection from such evils by higher temperatures are also well recognized. The benefits of a lower heat transfer liquid as a coolant to the stop-and-go type of driving and even normal winter driving are clear.

Paper on which this article is based is available from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

Air Force Mobilization

Continued from Page 24

utilization of extremely critical strategic materials. The Air Force, in cooperation with the Allison Division of General Motors and the General Electric Co., has entered into re-engineering contracts which have resulted in substantial reductions in the utilization of alloying elements such as columbium, cobalt, and nickel in regular production jet engines. Progress in these fields is not complete as yet and will not be completed until we have thoroughly service tested service test lots of production engines in flight operations. Results to date look promising.

Money

Money is a resource which in a way is a measure of all the other resources. The expenditure of effort and time is usually measured in dollars. If we can reduce the materials, facilities, machinery, and manpower required, we reduce the drain of any mobilization effort on the national economy. All our plans are aimed at this reduction. We, of course, plan with the aircraft industry to determine their estimated costs in money and all other resources to meet our mobilization requirements. We plan with the aircraft industry and the higher government agencies the methods of financing to be used where government financing of expansions of facilities is required.

Our plans will never be complete and our aim is to make such plans sufficiently flexible to be generally applicable in event of the ever changing programs and the world situation. They are of necessity keyed to the plans of the other services. I can say without reservation that the cooperation between the aircraft industry and the three armed services in their mobilization planning is of the highest order and for our mutual benefit.

(Paper on which this abridgement is based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members; 50¢ to nonmembers.)

IMPEDIMENTS TO

QUANTITATIVE measures of the chief tire life determinants—heat and abrasion—are emerging. These guides and other practices should help the fleet man get more mileage from his tires.

Tire temperature varies with speed, load, and inflation. It increases until the heat input equals heat dissipated. This is somewhat self compensating. Inflation pressure buildup due to heat reduces tire

deflection and flexing. The lower the flexing, the less the heat generated.

Fig. 1 shows an example of temperature buildup to the point where heat input and heat dissipation balance. In this case a balance was reached after about 100 miles at 33 mph. At this point, the speed was increased to 50 mph. Temperature at the tire shoulder increased from 190 to 240 F after driving 50 miles. Speed was then reduced to 33 mph again and temperature dropped in 50 miles to about the same that it had been before the speed increase.

Note that tire shoulder temperature at 33 mph was about 40 F above that of the air in the tube. There

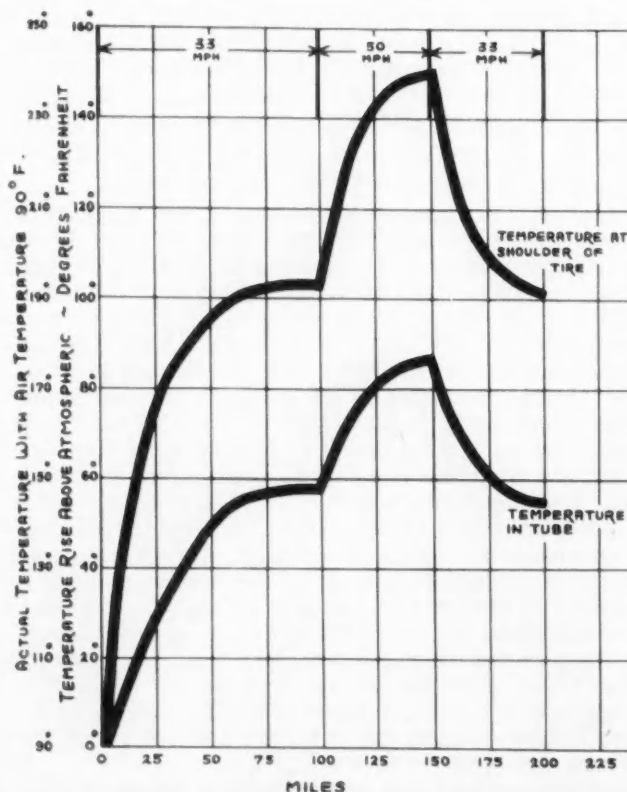


Fig. 1—These data demonstrate the effect of speed on tire temperatures. Equilibrium is reached at each speed. After a certain number of miles, heat input equals heat dissipated and the temperature remains static

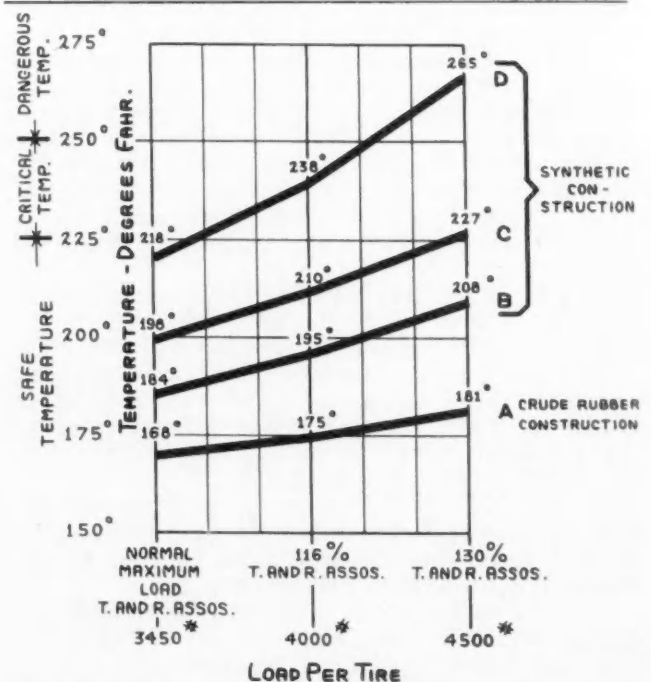


Fig. 2—Effect of varying load on temperature of tires at shoulder. The tire in this case was a 9.00-20, inflated to 65 psi when cold, and driven at 40 mph

TIRE LONGEVITY

BASED ON PAPER* BY

G. M. Sprowls, Manager, Highway Transportation Department, The Goodyear Tire & Rubber Co

* Paper "Tires and Tubes for Commercial Vehicles and Factors Affecting Their Service," was presented at SAE Summer Meeting, French Lick, Ind., June 8, 1950. This paper will be printed in full in SAE Quarterly Transactions.

is still a greater differential at 50 mph—about 64 F. The tire shoulder generally is the most critical area from a heat viewpoint.

Low atmospheric temperatures help dissipate heat generated by flexing. A more effective means is to take advantage of heat of evaporation. Tire temperatures drop quickly when passing over a wet road.

Increasing the load carried by the tire will cause greater flexing with an increase of heat generated. Result: a boost in tire temperature. This is shown in Fig. 2. Tire temperatures up to 225 F may be considered safe; 225 to 250 F critical—where failures from heat may occur; and over 250 F dangerous—where failures due to heat may be expected, especially if maintained for any considerable period of time. Note the increase in temperature with 16% and 30% overload on the tires.

There is evidence that truckers observe legal limits, especially if enforced, much more than any tire carrying capacity limits set up by the Tire & Rim Association.

Fig. 3 shows the right and left rear wheel loads of a number of tractors taken at random. Most of the weighings indicated that the left side was heavier

than the right. Legal limit in the area where these vehicles were used was 18,000 lb axle load or 9000 lb wheel load. Note that most of the loads are close to the 9000-lb line. These particular tractors were equipped with 10.00-20 dual tires on the rear, with a carrying capacity of 8000 lb. Thus a 500-lb overload was quite common.

Present axle weight limitation in Ohio is 19,000 lb. Fig. 4 gives the percent of total arrests for various loads—expressed in terms of percent of overload for 8.25-20, 9.00-20, and 10.00-20 size tires. Note that even on the 10.00-20 tires, all the vehicles on which arrests were made showed about 25% overload, and 25% were over 40% overloaded on 10.00-20 tires. The smaller size tires—9.00-20 and 8.25-20—would have been even more overloaded.

Some companies find it to their advantage to weigh wheel loads rather than axle loads. Reduction in tire overload is indicated by the dot chart in Fig. 5. Two separate Toledo-type platform scales make wheel-load weighing almost as fast as weighing axle loads. This method shows up an inequality in loads between the two sides.

Increasing inflation decreases deflection, with a corresponding drop in heat generation. This means lower tire temperatures. Fig. 6 shows what happened when inflation was increased from 65 to 85 psi, in test C. Temperature dropped from 210 to 195 F. An increase, when cool, of 15 psi over the Tire & Rim Association inflation schedule may be used to compensate for some unusual condition; but it almost invariably introduces failure from other conditions.

Impact may fracture a tire carcass. It may not be possible to detect this when it happens. Sometimes later, possibly days, depending on severity of the fracture, the tire may blow out due to the previous injury. High tire temperatures may be partially responsible for the final failure.

Why Tires Wear

Any operating condition that causes the tire to slip on the road will cause wear. Such conditions are: topography—curves and grades; road surfaces;

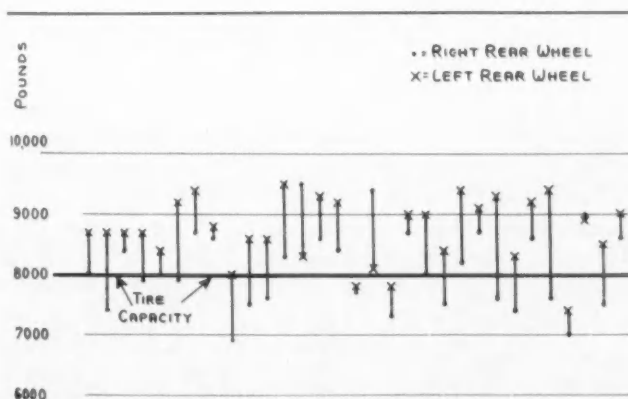


Fig. 3—Wheel weights taken at random exceed the 8000-lb carrying capacity of the tire. Legal limit is 9000 lb. Also, load on left side seems to be heavier than that on right

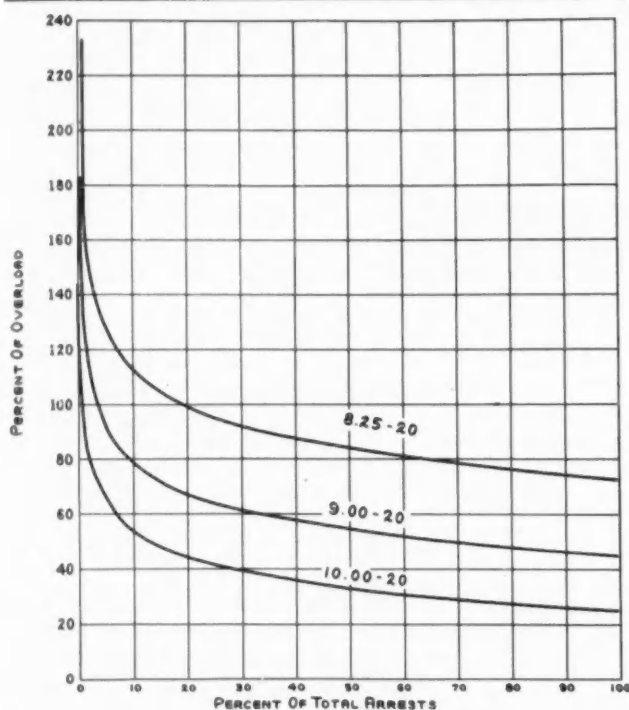


Fig. 4—Shown here are arrests in Ohio, which has a 19,000-lb axle weight limit, related to percent overloading of tires on single-axle units

acceleration and deceleration; load; and speed.

Many fail to appreciate the effect of curves and grades on tread wear. For example, we know two

different routes—one relatively straight and level and the other very winding, with long, steep grades. Tires on the winding route with grades, had over 66% faster rate of tread wear than those on the straight and level routes.

To get some measure of the degrees turned by the front wheels of the vehicles in negotiating the two routes, an instrument was designed to accumulate the number of turns of 1 deg, 2 deg, 3 deg, and so forth. The number of degrees on the winding route was found to be over five times that of the relatively straight route.

Some road surfaces are much more abrasive than others. Due to climatic conditions, some road surfaces are purposely made rough and abrasive for safety. Others may be more or less abrasive, depending on the type of sand used in the road construction. Large differences in average tire mileage were noticed in three areas. Photomicrographs of the sand used in road construction in these areas, Fig. 7, gave the answer.

Note that the grains of the sand in Fig. 7a are large and rounded. Sand of this type would not be used for sandpaper because it would not cut. The mileage of tires operated in this area was extremely high, indicating that abrasion was probably less than average.

The grains in Fig. 7b are small compared to the sand in Fig. 7a, and have relatively sharp edges. Sand such as this, if used for sandpaper, would cut, but rather slowly. In other words, it might be used for fine sandpaper.

The grains in Fig. 7c are not only large, but sharp. They would be used for coarse sandpaper. They would not only cut, but cut fast. For the same

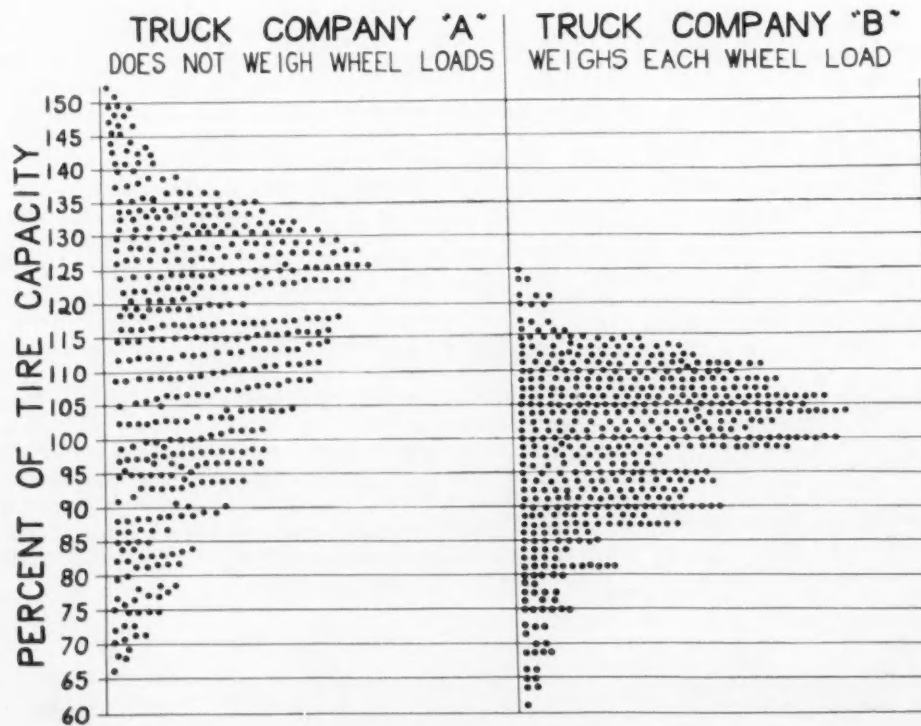


Fig. 5—This dot chart shows that one company which did not weigh its wheel loads had a much greater percentage of tire overload than another fleet that did

amount of tread wear, tires used where this type of sand was used in road construction gave only 58% as much mileage as where the large, rounded sand was used. The small sharp grain construction gave tire wear results 87% as good as the large, rounded sand.

In addition to the relative wear shown by the different sand types, this study brought out another very interesting fact. There was a greater differential between high quality and lower quality tread stock with the large, sharp grain sand than on the large, rounded grain sand. The more severe the service conditions, the greater is the advantage of quality treads.

Analysis of causes of tire removals by over-the-road operators shows that the percentage of tires removed because they are worn out is relatively low—22%. Some 35% are removed because of cuts and 31% because of carcass failures. Obvious correction for truck operators experiencing cut tires is to clean up terminals and loading platforms.

Next best remedy is to examine tires carefully at regular intervals and to remove all foreign material. Most road delays and failures do not happen when the tire is first injured. It may happen several days later. Early removal of foreign material from tires can eliminate many delays and road failures from cuts.

Reversing and Mating Tires

Tests show that tire rotation from front to rear can increase overall tire mileage. Tires first started on the front wheels, then moved to the rear, will give higher mileage on the average than keeping the same number of tires in the same position throughout their life.

But front wheels are apt to suffer from incorrect front end geometry, very often tough to rectify. Uneven tread wear may develop at low mileage which, if not retarded, may soon render the tire unfit for further service. In cases where such uneven wear is likely, exchanging the position of the right front tire with the left front one, before this unevenness becomes too pronounced, will even out the wear. In more severe cases, two or more reversals may be necessary.

In moving tires from front to rear where dual wheels are used, care must be taken to have each tire on the dual wheel bear its proper share of the load. This depends on the average operating con-

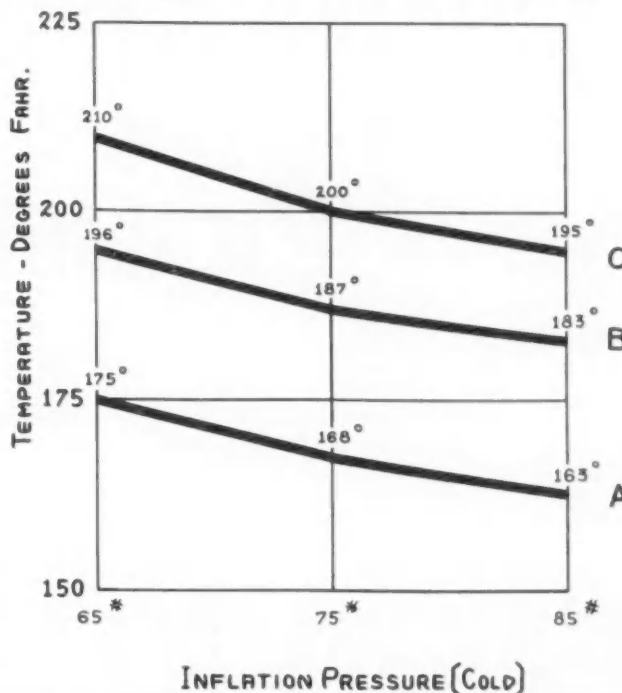


Fig. 6—Tests showed that the higher the inflation pressure, the lower the tire temperature. But this doesn't mean that high pressure will lengthen tire life, because it brings failure from other causes. The tire in this case was a 9.00-20, carrying a 4000-lb load, and driven at 40 mph

ditions. Some operations may require that the outside tire may be slightly larger in diameter than the inside; in other cases the reverse may be true.

It's easy to determine this by placing two tires of equal diameter on the same wheel and allowing them to adjust themselves by wear. Relative diameter of the two tires, after this adjustment by wear, is the proper relationship which should exist between the two tires for each to have the same wear rate. (This usually is not more than $\frac{1}{4}$ in. in diameter or $\frac{3}{4}$ in. in circumference.) Any other relationship will cause one tire to wear faster until this relationship is established.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

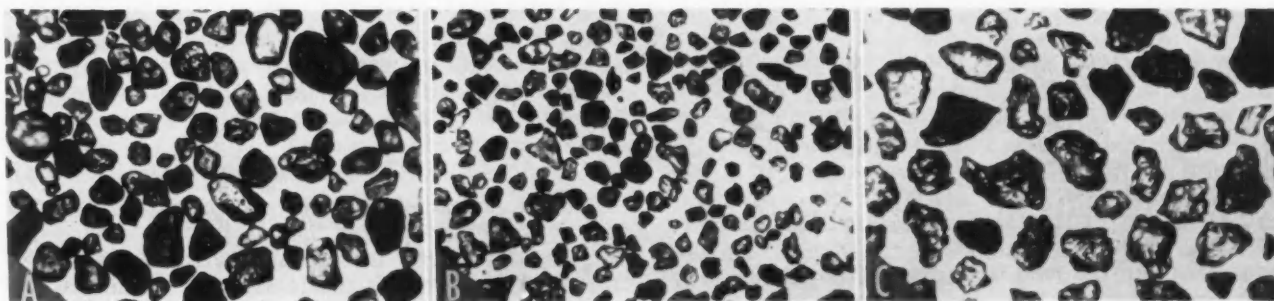


Fig. 7—Type of sand used in road surface construction affects tire wear. The large, rounded sand grains in "A" are easiest on tires. Sand consisting of small, sharp particles, such as those in "B," gives about 87% the tire wear of the sand in "A," while large, sharp sand particles, in "C," give only about 58% the mileage

PIONEERING DIESEL

CATERPILLAR'S trials and tribulations in searching for the answer to "what oil shall I use for my diesel engine?" reflect engine-building and petroleum industry cooperation that helped accrue gains to date. Additive oil development patterned alloy steel achievements. It progressed from use of additives as emergency drastic purging mediums to the constant aid of additives in prolonging engine life.

When Caterpillar put the diesel engine in production in 1931, who knew what to specify for lubricating oils? A petroleum specialist recently said, "At that time all we knew about lubricating oils was viscosity index and color."

Cry for Lube Spec

The what-oils-to-use question quickly raised its ugly but insistent head as production units continued to roll into the field. Recommending favorite brands was not tolerated by the company's service department. Constant demand was made on Research to develop a "specification." For almost four years we battled this situation before a satisfactory solution presented itself.

Using favored selected brands carried us along

satisfactorily when confined to three well-established brands. Later investigations confirmed the wisdom of these selections. They were mineral oils, refined from selected Gulf Coast crudes or naphthenic in character, with mild types of treatment. Fig. 1 shows the influence of straight mineral oils on ring sticking hours and piston deposition. Third lube classification was mild-treated paraffinic or naphthenic stocks.

In the laboratory, hours before ring sticking ranged from 1500 to 3000. In the field, engines operated between 3500 and 4000 hr for a year without major overhaul.

Fig. 1 shows the "ring sticking hours" condition to divide itself into three main categories; each of the three further divides itself into two separate areas. There seems to be an inverse relationship of ring sticking hours to degree of oil stock treatment . . . more drastic treatment yields fewer hours. Ring sticking hours was defined as time of test termination when blowby rate exceeded certain abnormal values. Minimum chemical change during finishing was apparently conducive to longer operation before ring sticking failure using straight mineral oils. Under the particular temperature gradient in the piston ring belt section, the naphthenic base oils gave longest service.

The oil selection problem did not clarify itself because the field constantly requested specifications. In December, 1933, various type lube evaluation tests were reviewed. Aside from the usual chemical tests of viscosity, neutralization number, carbon residue, and color, only other established test was the "Navy work factor."

Specs Limit Crudes

The Navy made this qualification concerning the test: "Specifications for lubricating oils embodying the standard tests are of value when they cover a narrow range of oils made from a crude and by process of refinement which are known to yield satisfactory oils; but when such specifications are used for oils made from widely different crudes, or

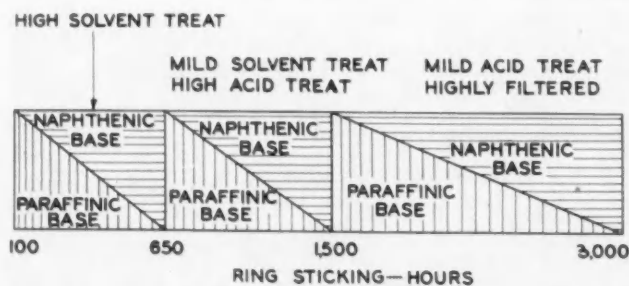


Fig. 1—When straight mineral oils were used as diesel lubricants, it was found that ring sticking hours was inversely proportional to degree of oil stock treatment

LUBE ALLOYS

EXCERPTS FROM PAPER* BY

C. G. A. Rosen, Consulting Engineer, Caterpillar Tractor Co.

* Paper "Pioneering in Lubricant Alloys (The H. D. Factor in Engine Lubrication)," was presented at SAE Chicago Section, March 14, 1950.

by widely different methods of refinement, their value is very doubtful."

The Navy set up a rigid specification involving some very complex chemical tests. These specifications were outlined to set up a preliminary method for eliminating undesirable lubricants and classifying the desirable lubricants. Those lubes satisfying the chemical and physical tests were then subjected to a "bearing machine test" for a 150-hr endurance run at given temperature and load conditions. This test and method was not satisfactory in evaluating cylinder lubes for internal combustion engines, particularly for diesels.

Film strength test machines were experimented with extensively. But this also fell by the wayside.

Finally, an "approved list" of lubricants was set up as the most practical way of assuring customers of proper oils to use. This was done despite complications arising in the service department's contacts with the petroleum industry. The brands recommended followed closely experience gained on large heavy-duty diesel engines. Then the cyclone struck!

Solvent refined oils found their way into service—the ultimate answer to a lube oil technician's prayers. This was hailed as a way to free the refining industry from limitations imposed by crude sources. Lube oil research was overshadowed by that on solvents with preferential solubility for certain hydrocarbon classes. That continued until commercial solvent treating processes permitted the refiner to reach the desired goal.

These lubricants apparently achieved the petroleum chemist's ideal because they satisfied certain chemical formulas. "They should," it was argued, "be the perfect lubricant for everything."

Brings Problems, Not Relief

But the high-speed diesel got into troubles galore. Ring sticking became epidemic in the diesel. Ring and cylinder scratching at times held up our production line because of the inability to break in engine completely without scratching and scuffing.

One of the original investigators in solvent refining wrote: "In developing the new solvent refining processes, it had been hoped that the oil produced by these methods would permit the solution of practically all lubrication problems. The new oils did show outstanding improvements in many respects, particularly as regards oxidation, stability, and carbon formation, resulting in cleaner and better operating engines in most cases.

"However, it soon became apparent that there was room for further improvements, especially in engines designed to give extremely high heat power outputs, or to operate continuously at comparatively high power outputs. With the best of the new oils, wear was starting to become a problem in all engines while ring sticking, piston deposition, galling or scratching of rings and liners, oil ring plugging, and bearing corrosion seriously limited the useful operating time between major overhauls in diesel and high output gasoline engines."

Matching Engines to Oils

These serious troubles did not relieve Caterpillar of sweeping off its own doorstep first, before hailing the new oils into court. Although comparative success had been achieved by a selected few of the older oils, the newer refining processes were here to stay. The problem was to adapt the engine as much as possible to these lubricants. Two most serious phases of the problem, at which Caterpillar aimed its investigations to find the causes, were: (1) ring sticking, and (2) ring and cylinder scratching.

The break-in problem was paramount at the factory. A solution was wanted to move engines over the production line. The company turned to Boerlage and Ricardo in Europe to discuss the situation. Both these men felt the intricacies of combustion merited immediate attention. Ricardo showed experimentally that combustion systems could vary considerably in their appetite to consume fuels without leaving dangerous deposits. He sent an engineer to the States to invaluate the combustion characteristics of the Comet and Whirlpool engines and the

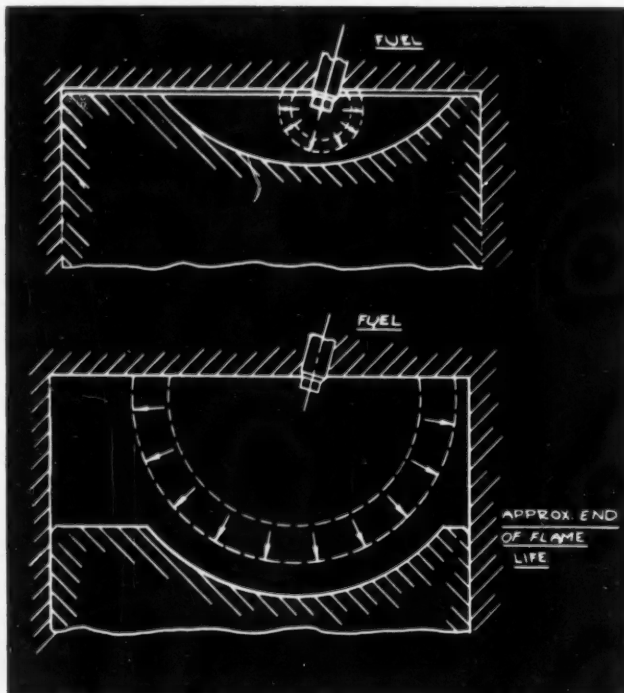


Fig. 2—Diagram of flame propagation in a precombustion chamber engine

precombustion chamber engine.

Final results showed the precombustion engine's combustion characteristic to be satisfactory. Experience and more recent experiments have borne this out. Today we feel that even though the precombustion engine has some undesirable features, it has an outstanding ability to burn a broad range of fuels with minimum deposits.

A crosshead engine, was designed in which the combustion chamber was fitted with a piston attached to a piston rod, which was free of any contamination from the crankcase. The main cylinder was lubricated by two injection tubes from a pressure type lubricator, as was common in typical large diesels. Oil drainoff was collected in a basin, and from there bottled into suitable containers for analysis.

This engine served well in developing our knowledge of lubes and lubrications. It also revealed the necessity of controlling the flame front from the burner tube in the main engine chamber. Fig. 2 illustrates the character of flame front finally achieved through a lower velocity single-holed orifice.

At first, however, the burner tube was fitted with multi-hole orifices which permitted the flame to impinge on the cylinder wall when the piston was far enough down the stroke to expose the cylinder surface. By feeding clean oil on the combustion cylinder walls and withdrawing used oil as fast as it drained into the catch basin, revealing deposits on cylinder surfaces were always available.

Ring and cylinder scratching was related to materials, surface treatments, and lubricants involved.

After the flame front was properly controlled a thorough search was made for long-life materials in cylinders and rings. Materials with best low wearing characteristics of liners and rings were not always satisfactory for rapid break-in. Finally good cooperating materials were found, but the break-in difficulty still persisted on the run-in stands.

Even careful manufacturing control, assembly, and break-in schedules did not fully alleviate the problem. At times, as high as 40% of the cylinder liners had to be replaced to put engines in proper operating condition before factory shipment.

Real improvement in break-in performance came from pretreating the cylinder liners. Early in 1936 the Standard Oil Co. of Calif. applied a caustic soda sulfur etching process the cylinder liner surfaces. This reduced break-in line failures from 40% to about 2%.

Ring sticking was concurrently attacked with cooperation of the West Coast petroleum industry. Ring sticking aggravation in use called for methods to relieve the customer's immediate difficulties in the field. Various type dopes and magic "mouse milk" materials were tested to free rings in engines in the field. Some of these proved very harmful.

Detergents Appear

Shell Co. of Calif. developed the most successful material, called a "piston cleaning fluid." This solvent contained a metal soap and permitted our servicemen to soak pistons and rings for hours. This freed rings in the grooves and permitted service to continue in the field with the same parts.

The solvent was applied in many ways. A service petroleum engineer in the Southwest found that he could extend hours of tractor operations in the field in troublesome areas by adding this solvent to the crankcase oil and purging the engines of their deposits. Further field and laboratory experiments followed. This solvent was added to crankcase oil in reduced quantities to permit continuous engine operation on this solvent and crankcase oil mixture. This was the forerunner of field attempts in operating diesel engines with a detergent type oil.

At this time, June, 1935, the Standard Oil Co. of Calif. proposed to us the trial of a compounded type crankcase oil developed in its laboratories. This oil was designed to disperse gummy and resinous products, such as those formed by lube oil deterioration plus materials added from the burning of fuel within the cylinder. It was designed to prevent these products from collecting in the dead spaces of piston rings and grooves.

Cooperative tests were set up. They led to a phenomenal laboratory run of over 4000 hr and paved the way for all-out recommendation of this lubricant in Caterpillar diesel engines. It was composed of an SO_2 treated Western base stock, to which was added an aluminum naphthenate with a small percentage of a synthetic ester, which appeared as diglycol laurate.

Thus alloys began to play their part in supporting a base oil to give the engine what it needs—just as years ago alloys in steel made the modern automobile possible. The ideal in solvent refining processes, to broaden base stocks for use in making lubricants, was achieved by adding alloys for what-

ever deficiencies were inherent in the base stocks. However, solvent refining process developers asked the test tube to be the criterion for developing and evaluating a lubricant, whereas in this case the engine was asked to reveal its needs. The diesel engine definitely said it could take advantage of alloys in lubricants to provide lowered maintenance to the customer.

Advent of this new development reversed a downward engine and tractor sales curve. Thereafter other petroleum companies cooperated with Caterpillar, resulting in a number of improved lubricant types.

These and other experiences led to publication of a list of "Superior Lubricants for Caterpillar Diesel Engines." The company felt that it was the "judge of its own satisfaction" and would issue certificates based on this policy. These detergent type lubes were transformed in chemistry to operate with copper-lead bearing materials and other better bearing materials.

General Motors Detroit Diesel found favor in these new noncorrosive detergent oils, cooperated in their development, and published lists of oils recommended for field testing. The list now contains over 1000 names.

Joint Effort Brings New Detergents

The war brought Ordnance into cognizance of the only established method of evaluating lubricants on a performance basis. Caterpillar instigated promotion of these practices for use by the Army. The 2-104B specifications were established by service requirements in CRC, promulgated as specifications by ASTM, and supported by Army Ordnance. This move established a universally recognized standard of quality oils on the basis of performance in engine tests than on test tube reactions.

This step, however, should be considered only the beginning.

Early in 1944 Caterpillar started to test a new supercharged engine, developed to operate at 150 bmepl. Some 21 engines were placed in the field to get a cross-section of performance. They were divided into three groups as to lubricant type used. One set operated on lower quality oils on the 2-104B list. A second oil group was chosen, of top quality within the 2-104B oils bracket. A third group of oils between the highest and lowest quality also was chosen.

2-104B Oils No Panacea

Engines operating on the borderline oils developed failures within 250 hr of operation. Ring wear and oil consumption were high, with considerable ring belt area deposition. The intermediate oils lasted 1250 hr; the better quality oils accumulated about 2350 operating hours.

About this time a dual field problem developed. Appearance of high sulfur fuels coupled with high load operation called for better lubricants to cope with the situation. It was later found that each phase of itself demanded a better type oil.

Because of encouraging experiments by Shell on a higher percentage additive oil, one of the supercharged engines was turned over for experimentation on this product. This engine was using 0.7% sulfur. But even under the high load operation expected; the engine ran 7300 hr with outstanding success.

This was the first clue to desirability of what is now known as the Series 2 type lubricant. It started the trend toward what is sometimes referred to as "high ashed oils."

Almost coincidental with this experience, troubles appeared in various locations throughout the country. They later proved to be instances of engines burning high sulfur fuels. Fig. 3a shows the service department evaluation of areas in which high wear and high cylinder depositions have been reported. Comparing this map with the one in Fig.

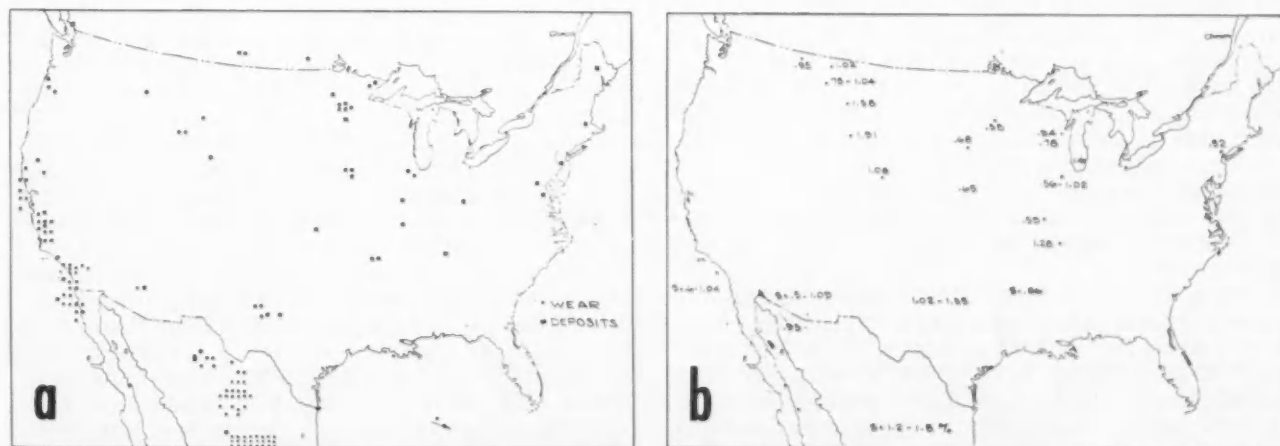


Fig. 3—The map in "a" shows location of reported cases of high wear and cylinder deposits, which were later traced to high sulfur diesel fuels. Distribution of high sulfur fuel is depicted in "b." Numbers represent percent sulfur. Note the relationship between the wear-deposit areas and the high-sulfur fuel distribution points

3b indicates the close parallel of these problems with the presence of high sulfur fuels.

Engine builders have reported extensive campaigns to evaluate the company's responsibility in solving these problems before getting the petroleum industry to incur expenses and investigate. Much improvement was made with materials and mechanical modifications to reduce cold corrosion type wear.

Two questions pop up: (1) How serious is the high sulfur fuel problem? (2) What is the justification for high additive type oils, such as Supplement 1 and Series 2 lubricants? Normal 2-104B oils have a maximum of 4 to 6% additive in the oil; Supplement 1 contains from 8 to 12%; Series 2 run from 16 to 20% additive.

As for the first question, high sulfur fuels are present in many areas in this country and the export field. It's spotty, but that's attributed to distribution. For example, if one company ships from a certain field having high sulfur crudes and another ships from a field with lower content crudes, it's possible to find both high and low sulfur fuels in the same state. Therefore, in high sulfur fuel areas, additional tools available in lubricants must continue to be provided. Series 2 oils make it easier to come closer to best results obtainable with low sulfur fuels.

Where's and Why's of Series 2 Oils

There are five uses for Series 2 oils. They are:

1. Where high sulfur fuels are available.
2. In high-output supercharged engines with or without high sulfur fuels.
3. In pipeline or oil field installations using available light crudes as fuel.
4. In localities where the low cost, light residual type fuels are economically available.
5. For extended oil change periods in all engines and in all types of services to lower overall maintenance costs.

Here's why:

- a. Service departments of engine builders are still plagued with troubles stemming from high sulfur fuels.
- b. Introduction of higher output engines, such as supercharged powerplants, definitely requires Series 2 type oils, field experience shows. Serious difficulties were encountered in the new V8 and V12 engines where users inadvertently lubricated equipment with 2-104B oils.
- c. Economics of pipeline operation have shown it desirable to use light crudes, so plentiful in pipeline systems. Series 2 oils make possible engine operation with economical maintenance when burning light crudes.
- d. Residual type fuels are becoming more and more prominent and inviting as a fuel source. High cost of diesel fuel, within 1¢ per gal of that of gasoline and even higher priced than gasoline in some places, justifies use of lighter residual fuels, so plentiful today. The customer will find Series 2 oils useful when burning these light residuals.
- e. Significant development in observing the effect of fuels and lubricating quality on oil change periods points up another gain with Series 2 oils. A formula

based on available experimental data for comparable engine state is:

$$H = \frac{K \times Q}{S}$$

where:

H = hours between oil change periods

Q = crankcase capacity in quarts

S = pounds of sulfur burned per hour

K = a constant, depending on the quality of lubricant used

K = 0.5 for poor type 2-104B oils

K = 1.2 for good quality 2-104B oils

K = 3.75 for Series 2 oils

Herein lies an extremely fertile field for exploration by the petroleum and engine industries. For example, take the Caterpillar D13000 engine operating at 80% load factor and burning 0.35 sulfur fuel. In this case, with a lower grade 2-104B oil:

Q = 34.7 qt

S = 0.185 lb per hr

$$H = \frac{0.5 \times 34.7}{0.185} = 93.8 \text{ hr between oil changes}$$

Using Series 2 oil under identical conditions in the same engine, the expression would be:

$$H = \frac{3.75 \times 34.7}{0.185} = 703.5 \text{ hr, or over seven times the}$$

oil life obtained on the poor type of 2-104B oil.

Assuming a price of 61¢ per gal for the 2-104B oils and 95¢ per gal for the Series 2 oils, the relative costs of lubricating oil per hour are as follows:

For 2-104B oils:

$$\frac{34.7 \times .61}{4 \times 93.8} = 0.0567¢ \text{ per hr}$$

For Series 2 oils:

$$\frac{34.7 \times .95}{4 \times 703.5} = 0.0117¢ \text{ per hr}$$

The figures speak for themselves. They indicate the real potentialities of extending oil change periods. The justification is economical maintenance when using Series 2 type lubricants.

Setting quality on averages is pervading evaluation test concepts. This recent tendency, developed in promoting changes to 2-104B requirements is deplorable. Would anyone fly an airplane in which the wing strut was tested for impact loads representing the average of those encountered in flight? It is equally inconsistent to set short-time test requirements for determining the performance of lubricants on the basis of softened average conditions.

These empirical constants, determined in practice, show the great need for revising 2-104B oils. Why shouldn't quality to determine a performance requirement for a short-time test be based on realistic values which the industry encounters?

Let us not go back to the confusion of brands or to use of cookbook formulas of complex chemical deduction. Let us still ask the engine what it needs to get along. At least let us live by the facts. The future involves newer problems demanding continued effectiveness of the well-established constructive exchanges through cooperative agencies.

Paper on which this article is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.

The Case for the Turbojet

BASED ON PAPER* BY

Winnett Boyd, Gas Turbine Engineering Division, A. V. Roe Canada, Limited

* Paper, "The Case for the Turbojet," was presented at the SAE National Aeronautic Meeting, New York City, April 18, 1950.

IN presenting the case for the turbojet, it is desirable to divide the cruising speeds of transport aircraft into three categories:

1. 500 mph or better.
2. 400-500 mph.
3. Up to 400 mph.

For cruising speeds of 500 mph and over, there

seems to be no argument about it. The turbojet is the only possible solution, for no other existing type of engine can compete with it.

For cruising speeds of 400 mph and under, the turbojet can't possibly be considered—in this range, it is the turboprop versus the piston engine.

It is in the 400-500-mph range that the case for

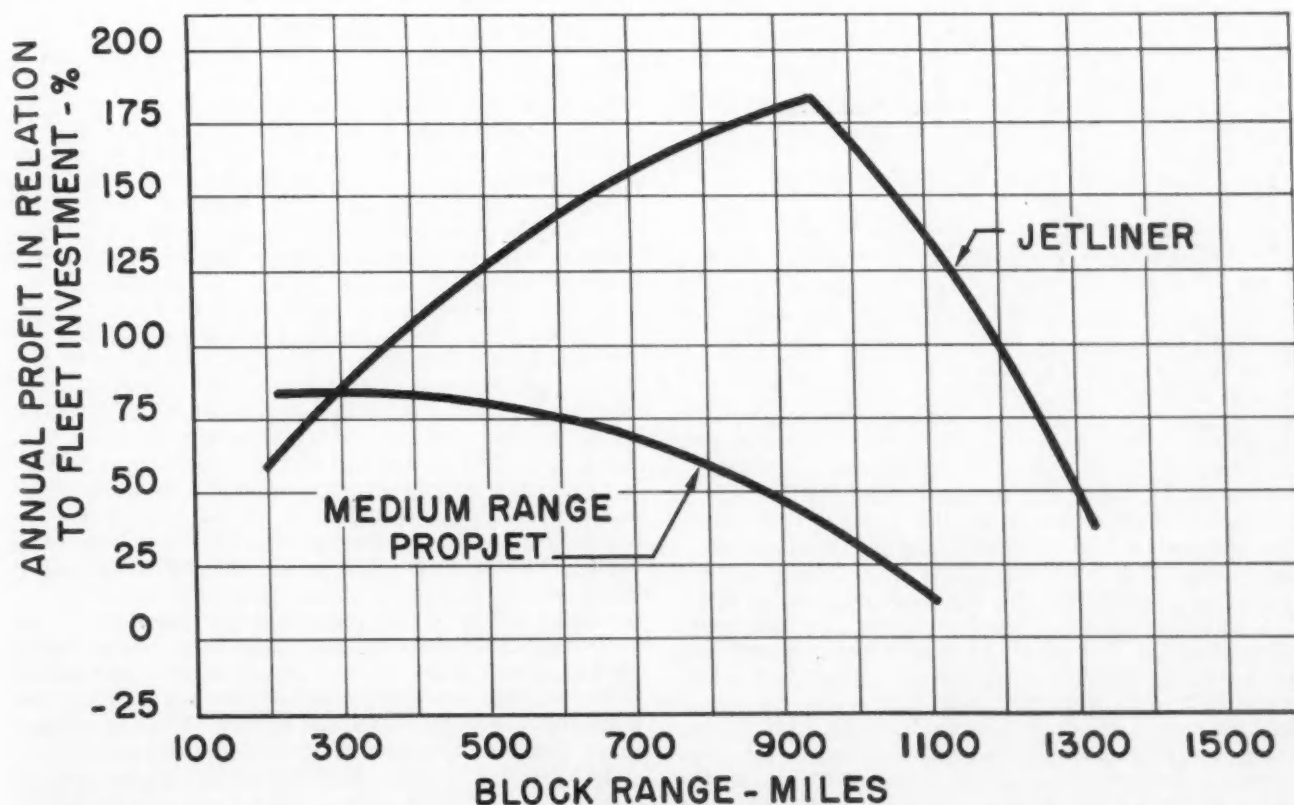


Fig. 1—Comparative earning power: Jetliner versus medium-range turboprop—70% load factor, 50¢ per ton-mile revenue, with fuel at 15¢ per U. S. gal

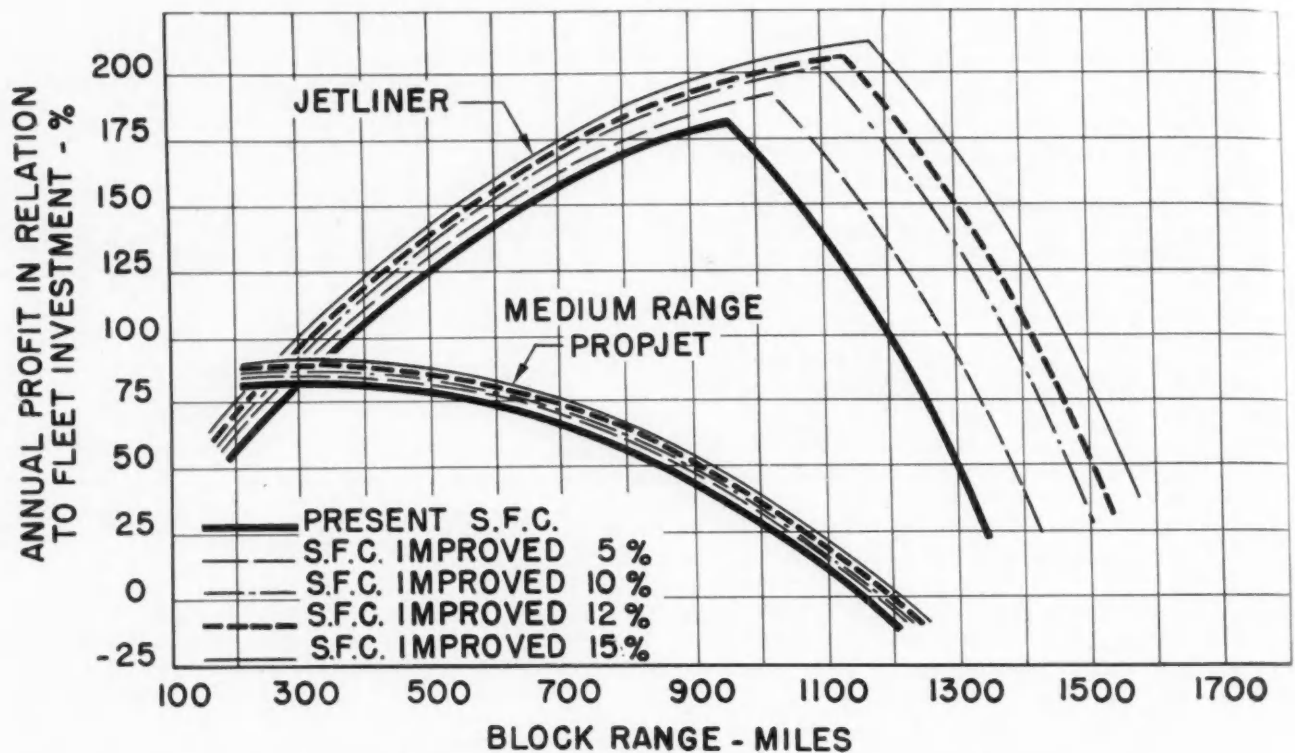


Fig. 2—Effect of improved sfc on earning power: Jetliner versus medium-range turboprop

the turbojet versus the turboprop and the piston engine has to be argued for transport aircraft.

The advantages of the turbojet for this range will be discussed under the following headings:

1. Economy.
2. Reliability and overhaul life.
3. Comfort.

Economy

Many competent authorities have investigated the economics of the turbojet transport and, despite the rather sizable thirst of the turbojet for fuel, the results have always been favorable. Careful calculations made by the author's company show that the turbojet transport will outperform many of its slower turboprop and piston-engine rivals on a large number of airline routes, in terms of economy. These statements will probably evoke considerable discussion and criticism on the ground that turbojet transports have higher costs per ton-mile than conventional transports. This objection is correct, as far as it goes, but the ton-mile basis of comparing transport aircraft has been made obsolete by the advent of the turbojet. In short, the cost per ton-mile was a satisfactory basis of comparison when aircraft speeds were all about the same, but when the block speed of one aircraft is 50-75% higher than that of the other, the proper criterion for comparing the revenue-producing possibilities of the two is the net unit earnings per ton-mile multiplied by the block speed.

In other words, the airplane that flies faster will cover more miles in a given year and, although its

net unit earnings may be smaller, its gross earnings per year will be greater, as shown in Fig. 1.

It should be noted that the calculations made for Fig. 1 took into consideration adequate allowances for stand-off and alternate airport and thus, because of existing methods of traffic control, are particularly compromising to the jet plane. On this score, Hetzel¹ has demonstrated that, with optimum partial engine operation, the maximum stand-off endurance of turbojet transports is independent of altitude, which, up to now, has not been clearly understood and has always been used as a criticism of jet planes. This means, however, that in existing jet transports the pilot has to shut down some of the engines to realize maximum stand-off endurance at low altitudes and to restart them before landing, but this procedure will be largely eliminated in the future by engines that have much flatter sfc versus power curves.

Since the turbojet transport is economically competitive with existing engines, which, admittedly, have high fuel consumptions, it is interesting to see what improvements will result from lower fuel consumptions. In this respect, the turbojet plane is in a class by itself, since it becomes very attractive if engines with, say, 12% lower fuel consumption are available. Fig. 2 shows the effect of such an improvement for both the turbojet and the turboprop.

The jet engine will undoubtedly be more reliable

¹ See Aero Digest, Vol. 58, June, 1949, pp. 42-44, 92: "Emergency Operation of Turbojet Transports," by E. Hetzel.

than its competitors because of its relatively simple nature in comparison with the complications of the piston engine, with its connecting rods, valves, pistons, cams, propellers, and so forth, and the turboprop with its large reduction gear, propeller, and "box of tricks" to maintain the correct relationship between engine speed, propeller power, and jet pipe temperature.

Simplicity of Jet Engine

In other words, although the jet engine may seem complicated to the nontechnical person, it is actually considerably simpler than the turboprop or the piston engine and sticks closer to the fundamental that to do a given job the simplest mechanism is always the best. It is on this fact, as well as on the performance of these engines to date, that a long and reliable life can be predicted.

This better reliability will be reflected not only in safety but in actual cost of operation. The turbojet transport of 1956 will be cheaper to operate than existing ones not only because of better fuel economy but because of much improved engine reliability and considerably longer periods between overhauls.

In fact, a 1000-hr overhaul life seems entirely possible for the commercial turbojet transport of 1956. This period is equivalent to 1500-1750 hr for a piston engine because, for each hour of flight, the turbojet will travel 50-75% farther than the piston-engine plane.

Furthermore, it is thought that there will be no major replacements during the first engine overhaul, as it is expected that these will be limited to the main bearings, fuel pumps, a few nozzle guide vanes and turbine blades, insulating blankets, and perhaps nozzle box liners. The 2000-hr overhaul is expected to be a complete rebuild and will include replacement of all gears and bearings, blades, nozzle box liners, tail cone, and the like. In other words, most of the working parts will be replaced. This will put the engine in shape for another 2000 hr, with an overhaul at the midpoint. After this, that is, at 4000 hr total engine running (equivalent in miles to 6000-7000 hr for a piston engine) it is expected that the second set of working parts will be worn out and the main castings and other parts will be deteriorated to the point where the entire engine will have to be discarded.

Engine maintenance between overhauls will probably be limited to fuel and oil filter cleaning, replacement of flame tubes or combustion-chamber liners every 500 hr, replacement of some fuel and oil line hoses, and cleaning the spark plugs every 100 hr.

To indicate the degree of reliability that jet engines are now achieving and to substantiate the statements just made, the endurance run of the first Avro Orenda engine will be discussed.

This engine ran for 784 hr without a major overhaul, during which time it completed the 50-hr flight clearance or 25-hr special category tests, as well as the 150-hr endurance tests, of the United States, the United Kingdom, and Canada—one right after another.

In addition it also completed 209 hr of miscel-

laneous running, including numerous accelerations and stalls, to get the correct setting on the acceleration controller.

All this running was done without derating the engine in any way and the endurance run was terminated only by a member of the test crew accidentally dropping a bolt and a package of Schick injector razor blades into its intake. No engine blades were broken but their leading and trailing edges were badly burred. The rest of the engine was in good shape and would have run considerably longer. The only maintenance done during this endurance test was to replace certain lengths of flexible hose, the fuel pumps after 500 hr, the flame tubes or combustion-chamber liners after 300 and 600 hr, and six nozzle guide vanes, which got damaged accidentally.

Take-off jet pipe temperature was maintained at 700 C as measured by stagnation thermocouples and a performance run about 2 hr before the accident occurred indicated that the take-off thrust of the engine had dropped only 75 lb after all this running. The engine was on the test stand from July 5, 1949 to Nov. 10, 1949 and, allowing for a two-week plant shutdown, this averages out to about 7 hr per day, including Saturdays and Sundays. It might be mentioned that this average daily running could have been improved if it hadn't been for the neighbors, who strenuously objected to our running the engine at night or, indeed, too early in the morning. As further evidence that the Orenda had not been babied to get this reliability, the following breakdown of all its development running to date is given:

1. 4.6% at take-off thrust or better.
2. 6.2% at climb (92% of take-off thrust).
3. 30% at maximum continuous cruise (81.5% take-off thrust).
4. 46.3% at 65% of take-off thrust and above.

The endurance run was made on the third rebuild of the Orenda No. 1. On the two previous builds a total of 192 hr was logged, so that nearly all the engine components, including main bearings, turbine blades, nozzle guide vanes, nozzle box liners, tail cone, tail pipe, and, of course, all of the cold end of the engine, had run almost 1000 hr when the accident occurred. With the exception of the blades, the engine was in good shape and it is therefore going to be rebuilt and its running continued. Thus, there is pretty good evidence for predicting 1000 hr between overhauls with very few replacements, either between or during overhauls.

Comfort

The comfort in transport planes using piston engines, while satisfactory, if one doesn't know any better, is no match for that in turboprop and turbojet aircraft. Although it could conceivably be improved by better upholstery, better seats, more attractive internal furnishings, and prettier stewardesses, these improvements would be more in the nature of remedies than cures, for it's the engine noise and vibration that cause the trouble.

(Paper on which this article is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

More Payload for Same GVW

WHETHER or not the gas turbine will succeed in competition with conventional truck engines depends partly on the answer to this question:

Does the gas turbine's lighter engine weight justify its heavier fuel consumption?

On the basis of the Boeing Model 502 installed in a hypothetical 68,000 lb GVW truck, the answer is:

Yes—if the distance traveled between refuelling points is not too great and if the truck is designed so that the saving in engine and chassis weight is useable for added payload.

This conclusion is reached by setting up the weight comparison shown in Table 1, then performing the calculations carried out in the box accompanying this article.

The calculations show that for the conditions assumed, the break-even operating distance between terminal points is 460 miles. For closer terminals, the turbine-powered truck will be slightly more economical than the conventionally powered truck, if the weight saving is used as added payload capacity. The shorter the distance between refuelling points, the greater the turbine's advantage.

The equation used provides a yardstick for fair comparison of the two types of power trains. Factors common to both types are automatically cancelled. For example, tire costs, driver wages, overhead, and depreciation do not and need not enter into this comparison, since they are common to both. Actually if any difference exists between the two, the turbine truck would be more advantageous because of lessened driver fatigue, possibility of decreased tire wear, and reduced repair and servicing time.

Factors which lend the greater emphasis to the comparison are fuel consumption and price. Unfortunately, at this time we do not have exact figures on the sustained highway operating characteristics of the turbine truck. Values used for fuel rate in the calculations are approximations. We have only provided a means of comparison of the two types of operation.

The turbine appears to have a worthwhile advantage with trucks operating less than 400 miles between refuelling points. This advantage would be broadened if the turbine burned Navy boiler grade

or one of the less refined fuels, which are cheaper than diesel oil. This is a definite possibility in the case of the turbine truck and an advantage which the conventional diesel engine cannot readily surmount.

Similarly, the gas turbine truck suffers less by comparison with a gasoline-powered truck than with the diesel-powered truck.

The method of comparison can be applied to the turbine engine burning Navy-boiler-grade fuel. This fuel weighs 13.2% more than diesel fuel, and its cost is 69% of the cost of diesel fuel after taxes are applied. Substitution in the equation shows that the

Comparison of

Assumptions for diesel truck are:

- Tractor and semitrailer combination grosses 68,000 lb.
- Powerplant is one of the commonly used diesel engines.
- Combination operates in intercity long-haul service with refueling only at end of run.
- Payload averages 40,000 lb, or 20 tons.
- Diesel fuel consumption averages 4.5 mpg.
- Lube oil consumption is 1 qt per 100 miles of diesel operation.
- Average revenue per intercity payload ton-mile is \$0.10.
- Diesel fuel costs \$0.167 per gal or \$0.037 per mile.
- Lube oil cost is \$0.20 per qt, and consumption is 1 qt per 100 miles of operation, so that cost is \$0.002 per mile.

The turbine-powered truck will differ in these respects:

The weight saving (according to Table 1) through use of the turbine and planetary transmission and elimination of auxiliary transmission is 2981 lb.

Total payload is 40,000 lb plus 2981 lb, which is 42,981 lb, or 21.49 tons.

Turbine fuel consumption per mile is assumed to be three times the diesel rate of 4.5 mpg or 0.222 gpm. Therefore, turbine fuel weighs 3(0.222) or 0.666 gpm or 0.0025 tons per mile. Cost of turbine fuel per mile is 3(\$0.037) or \$0.111.

Lube oil requirement is disregarded because it would be only about 1% of diesel requirement.

W. M. Brown, Project Engineer, Kenworth Motor Truck Corp.

* Paper "Gas Turbine Propulsion for Ground Vehicles?" was presented at SAE National West Coast Meeting, Los Angeles, Aug. 14, 1950. This paper will be printed in full in SAE Quarterly Transactions.

Possible with Truck Turbines

break-even point will be 562 miles of nonrefuelling operation. Here again, the operating radius must stay well below 562 miles to show a noticeable net gain, but the possible profit margin has increased over the condition where both types of truck operate on the same fuel.

Making Use of Weight Saving

The total weight saving possible over a conventional truck engine and transmission installation is about 3000 lb. Additional fuel weight for 300 miles of operation is roughly 1000 lb. So there would be

2000 lb of additional weight to be applied at the front axle to bring the loading up to the legal limit.

It would probably be possible to shift some of the heavier components forward over the front axle. This could include batteries, tools, and fuel—but their total weight would not make up the additional requirement. The balance of the weight necessary for front axle loading must be obtained by shifting the reactions from body and payload forward.

Making use of the possible weight saving of the turbine installation will be no simple matter and will require something different from present constructions. Fig. 1 shows three possible constructions,

Revenue with Turbine and with Diesel

Ratio of turbine truck revenue to diesel truck revenue is:

$$\frac{\text{Turbine truck revenue}}{\text{Diesel truck revenue}} = \frac{(S)(R)(W_t - FS) - (C)(S)}{(S)(R)\left(W_d - \frac{F}{3}S\right) - \frac{C}{3}(S) - (L)(S)}$$

where S = operating distance between refuelling points, miles

W_t = turbine payload, tons

W_d = diesel payload, tons

R = revenue, \$ per ton-mile

F = turbine fuel weight, tons per mile

$\frac{F}{3}$ = diesel fuel weight, tons per mile

C = turbine fuel cost, \$ per mile

$\frac{C}{3}$ = diesel fuel cost, \$ per mile

L = lube oil cost, \$ per mile

The above ratio equals unity at the break-even value of S . Solving for the break-even value of S gives:

$$\frac{(S)(0.1)(21.49 - 0.0025S) - (S)(0.111)}{(S)(0.1)\left(20 - \frac{0.0025}{3}S\right) - (S)(0.037) - 0.002S} = 1$$

$$S = 460 \text{ miles}$$

For a distance S between refuelling points of 200 miles, the revenue ratio is 1.988/1.945, or 2.2% more for the tur-

bine truck than for the diesel. This amounts to \$44 increased revenue per year based on \$2000 yearly net profit per truck. For 300 miles of operation, between refuellings, however, the operating advantage of the turbine over the standard diesel truck drops to 1.4% or \$24. Similarly, with 400-miles operation, the difference is only \$10.

Table 1—Engine Installation Weight Comparison

Component	Diesel Engine lb	Model 502 Gas Turbine
Engine (dry weight)	2475	260
Radiator	285	—
Water (engine, hosing, and radiator)	109	—
Oil	56	7
Fuel Tanks and Brackets	240	385
Battery (and ignition system if any)	280	140
Air Filter	34	—
Lube Oil Filter	75	2
Fuel Filter	10	10
Exhaust System	90	125
Main Transmission and Clutch	481	600
Auxiliary Transmission	456	—
Engine Mounting	73	10
Air Compressor (for brakes)	—	40
Rubber Coupling	—	20
Oil Cooler	—	25
Sound Insulation (engine compartment)	—	50
Silencer	—	9
Total Installation Weight	4664	1683

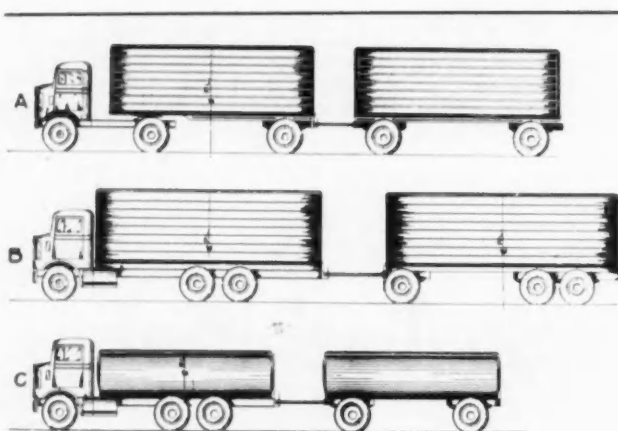


Fig. 1—Truck and trailer combinations for turbines

each suited to the state highway-loading laws of a particular area. Each truck shown is of the cab-over-engine design—which makes best use of the turbine's weight saving. Each combination is arranged to take maximum advantage of the loading regulations in the area for which it is designed.

Arrangement A necessitates lengthening the tractor wheelbase and in effect moving the fifth wheel forward to throw a larger percentage of payload on the front axle. This procedure would require some careful investigation to accomplish the desired result.

In Arrangement B, the wheelbase is lengthened and the payload and body centered farther forward on the wheelbase. Also, a portion of the payload could conceivably be allowed to extend over the cab roof to achieve maximum allowable front axle loading.

Arrangement C calls for lengthening the wheelbase.

Where payload reactions are transferred forward, redesign for turbines requires changes in front axle springing to accommodate the larger changes in

front-end loading between the fully laden and the unladen or light conditions.

The Boeing Model 502 gas turbine powerplant is already being tested in a Kenworth truck (see SAE Journal, Vol. 58, No. 8, August, 1950, pages 53-57, 72) together with an experimental semiautomatic planetary transmission. Purpose of the tests is to acquire service data for the Navy Bureau of Ships, sponsor of the development of both turbines and transmission.

The test vehicle is shown in Fig. 2. Starting at the front of the truck, principal units of the power train are the turbine unit (including air-intake silencer), coupling, marine reverse gear with 1 to 1 ratio in both forward and reverse, a seven-speed plus reverse planetary transmission, a Spicer 8031 three-speed auxiliary gearbox, and finally the rear-axle bogey hook-up. The marine reverse gearbox serves two purposes: (1) It transforms the rotation of the powerplant, which is opposite from conventional truck engines, to the conventional rotation required by the rest of the power train. (2) It makes possible power retarding.

Of course, the test vehicle is an adaptation of available units, for test purposes only.

Model 502

Future plans for the Model 502 as a truck powerplant call for a combination reduction and reverse gearbox with automotive rotation on the output shaft. The shaft will drive through a pair of universal joints into a planetary transmission with six forward speeds and no reverse. The output shaft of this transmission will drive directly into the gear axle assemblies. No auxiliary transmission is contemplated for ordinary highway freight installations. Proper spacing of gears will give sufficient top speed and gradeability in the lowest gear without an auxiliary transmission.

(Paper on which this abridgement is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

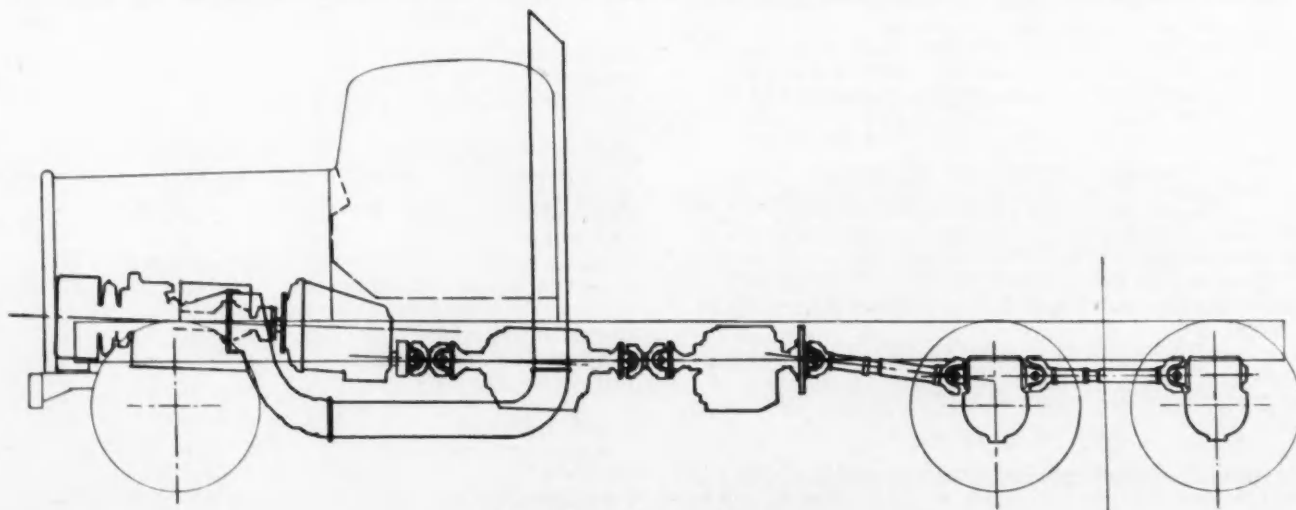


Fig. 2—Arrangement of test truck

D. P. BARNARD



To Get 1949 HORNING MEMORIAL AWARD

DR. DANIEL P. BARNARD IV, research coordinator for Standard Oil Co. (Indiana) will receive the 1949 Horning Memorial Award at the 1951 SAE Annual Meeting in Detroit. His lecture will be titled "The Role of Fuel in Engine Development."

He will receive the award "in recognition of distinguished active service in the field of mutual adaptation of fuels and engines."

Barnard is recognized as an authority on petroleum and its products. Many of his articles have appeared in professional and trade publications. He is president and a director of the Coordinating Research Council, having served with its predecessor, the Cooperative Fuels Research Committee, since 1923. He is also chairman of the automotive research committee of the American Petroleum Institute Division of Refining and a member of the NACA Subcommittee on Aircraft Fuels and Lubricants.

He joined Standard Oil Co. in 1925 as assistant director of its Whiting, Ind., refinery to establish the company's automotive engineering laboratory. In 1938 he became an associate director of research and in 1945 was transferred from Whiting to the general office in Chicago. He became research coordinator in 1948.

Before going to work for Standard Oil, Barnard served for three years in the research laboratory of applied chemistry at the Massachusetts Institute of Technology, where he had received the degrees of master of science and doctor of science. His undergraduate work was done at the University of Delaware.

SIDNEY WILLIAMS



Named 1950 BEECROFT MEMORIAL LECTURER

SIDNEY J. WILLIAMS, assistant to the president of the National Safety Council, has been chosen the Fourth David Beecroft Memorial Lecturer for his "substantial contributions to the safety of traffic involving motor vehicles."

The Beecroft Memorial Lectures are the result of a \$2500 bequest to the Society by the late David Beecroft, SAE President in 1921. Beecroft's will specified "ten awards of \$250 each to be awarded . . . for meritorious contributions to the improvement of traffic conditions. . ."

Williams is well known as a leader in the field of safety. He joined the National Safety Council staff as chief engineer in 1918, was made director of the public safety division in 1924, general manager in 1944, and rose to his present position a year later. He is the author of two books on safety, and has contributed to many books, encyclopedias and periodicals.

He took an active part in the National Conference on Street and Highway Safety, the President's Highway Safety Conference and other conferences, joint committees, and training courses on traffic safety. In 1938 he received the CIT Safety Foundation grand award for the greatest contribution to public safety.

At present he is chairman of the National Committee on Uniform Traffic Laws and Ordinances, the joint committee which handles the Uniform Vehicle Code and Model Traffic Ordinance; chairman of the Safety and Industrial Health Advisory Board of the U. S. Atomic Energy Commission; and executive director of the President's Conference on Industrial Safety.

Thermal Gains Seen As Diesel

FUNDAMENTAL thermodynamic relationships explain why the diesel yields greater fuel economy and power per cubic inch displacement than the gasoline engine. This stems from the inherently higher thermal efficiency of the diesel engine.

Fig. 1 shows the fundamental relations between the thermal efficiency of spark-ignition and compression-ignition engines. These indicated efficiencies are based on the assumed conditions in Table 1. Indicator cards based on these conditions are representative of cards from typical engines.

The ordinates are indicated thermal efficiency. The abscissae are percent theoretical, or stoichiometric, fuel-air ratio. The left side of the diagram shows the indicated thermal efficiency of compression-ignition engines. The cross-hatched area, from 14 to 18 to 1 compression ratio and 10 to 97% fuel-air ratio, indicates the range of compression ratios and fuel air ratios covered by modern diesel engines.

In a similar way, the right side of the diagram applies to spark-ignition engines. The compression ratio lines for the spark-ignition constant volume cycle lie above those for the compression-ignition mixed cycle engines, since the constant volume cycle is the more efficient of the two at any given ratio.

The fully cross-hatched area covers present day commercial engines from 5.5 to 7.5 to 1 compression

ratio, and fuel-air ratios from 112% for maximum power to 82% at the leanest limit that can be ignited by a spark. Mixture ratios at part load must be maintained between these same narrow limits so the load is varied by reducing the amount of mixture entering the cylinder by throttling. The lightly-sectioned area has been extended to include engines up to 12.5 to 1 compression ratio, since such engines have been developed experimentally for 100-plus octane gasoline.

Note that the efficiency of the spark-ignition engine falls off rapidly at fuel-air ratios above 100%. This is due to the loss from unburned fuel in such over-rich mixtures. This condition is normal, however, in spark ignition engines, since it results in an increase in maximum power at full throttle; it may be unavoidable in some cylinders at all loads if distribution is unequal.

Since the diesel engine operates at fuel-air ratios below 100% at full load, and down to as low as 10% at no load, there is never any condition where fuel is wasted from over-rich mixtures.

These diagrams reveal several of the fundamental characteristics of the diesel engine that account for its excellent fuel economy. They are:

1. The work done on the piston by a given amount of fuel, or the indicated efficiency, is greater for the diesel engine than the spark-ignition engine at all compression ratios attainable with present day gasolines—5.5 to 7.5 to 1.
2. The proposed 12.5 compression ratio engine using 100-plus octane gasoline approaches, but does not equal, the efficiency of the corresponding high compression diesel engine.
3. There is a distinct loss in efficiency in most spark-ignition engines due to the practical necessity for using over-rich fuel-air ratios under many operating conditions.
4. The diesel engine operates with an excess of

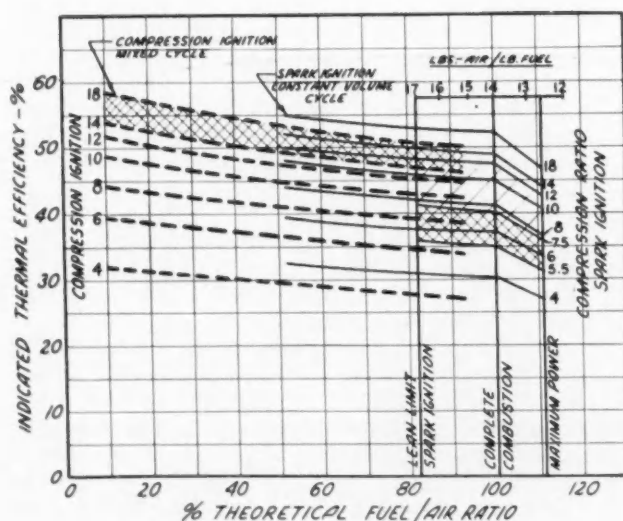


Fig. 1—This comparison of the thermal efficiencies of spark-ignition and compression-ignition engines shows that diesel engines today (upper cross-hatched area) yield more work for a given amount of fuel than present gasoline engines (lower cross-hatched area)

Table 1—Assumed Engine Conditions

Charge pressure	14.7 psi abs
Charge temperature	60 F
Direct heat loss	20%
Combustion efficiency	100%
Scavenging efficiency	100%
Compression-Ignition Cycle	
Constant volume	40%
Constant pressure	60%
Spark-Ignition	
Constant volume	100%

Edge Over Gasoline Engine

EXCERPTS FROM PAPER* BY

F. Glen Shoemaker

Consulting Engineer, Detroit Diesel Engine Division, GMC

* Paper "The Fundamental Advantages of Diesel Engines for Trucks," was presented at SAE National West Coast Meeting, Los Angeles, Aug. 16, 1950.

air throughout the whole load and speed range, or at the most efficient fuel-air ratio.

5. Efficiency of the diesel engine improves still further at part load due to its ability to run on very lean mixtures.

These are computed indicated efficiencies. It has been shown by others that the relation between the brake thermal efficiency and compression ratio varies in the same manner as the theoretical curve or air-cycle efficiency. The brake thermal efficiency of actual engines may vary somewhat due to such differences as combustion, mechanical friction, and pumping losses.

Achieve Theoretical Gains in Practice

Power and fuel consumption data from typical gasoline and diesel engines show that these fundamental thermodynamic relations affect actual engine performance in a similar manner.

Fig. 2 shows the brake specific fuel consumption over the entire speed and load range of a modern commercial gasoline engine. These complete data were available only from the 100-hp engine shown. Typical performance data from large truck type engines of 150 to 250 hp with compression ratios of 5.5 to 6.0 to 1, give brake fuel consumption figures slightly higher than shown for the smaller engine. Thus the comparison with a 200-hp diesel engine is believed to be, if anything, favorable to the gasoline engine.

The carburetor of the engine shown in Fig. 2 was calibrated for best economy at part load and for maximum power at full throttle. Actual economy setting of a commercial carburetor for a multi-cylinder engine is always richer than the lean limit for ignition by the amount required to cover variations in distribution, acceleration, temperature changes, and so forth. The full-throttle setting is usually richer than the theoretically correct proportion to increase the maximum power rating and to avoid detonation. As shown by the "fishhook" curves, this results in an increase in brake fuel consumption of at least 10% at full load.

Fig. 3 shows the corresponding characteristic of a modern commercial diesel engine. The readings were taken from a stock engine without any special

adjustment of either fuel or air. The diesel engine always operates with an excess of air in the cylinder. Therefore, there is never any appreciable amount of unburned fuel in the exhaust.

The diesel engine operates inherently on the leanest possible fuel-air ratio without any limitations as to combustion range, distribution errors, carburetor adjustments, atmospheric conditions, or fuel quality. The engine is "Scotch" by nature. In the speed range of this engine, as used for truck service, 1200 to 2000 rpm, the full-throttle fuel consumption is only 3 to 7% above the minimum.

An "envelope" curve has been drawn through the minimum fuel consumption points at each speed. The full-throttle points have also been connected by a "full rated power" curve. Engines in actual service operate between these two curves depending upon the speed, load, and gear ratio of the vehicle.

To simplify the comparison of the two engine types on a fuel efficiency basis, these "envelope" curves of best fuel economy, together with similar curves of several other modern gasoline and diesel engines, are shown in Fig. 4.

The ordinate is brake specific fuel consumption

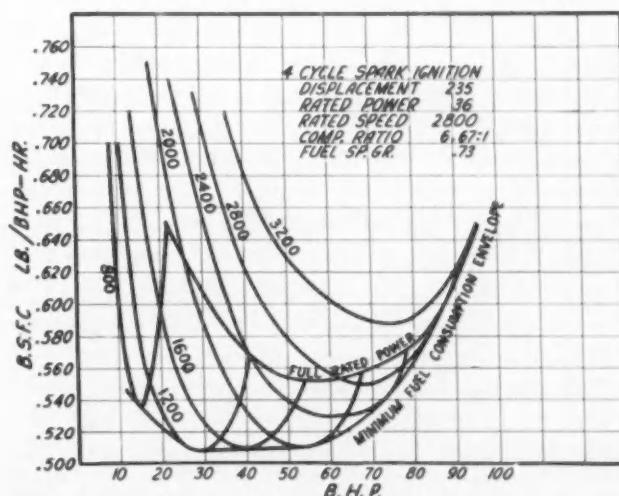


Fig. 2—Typical fuel consumption characteristics of a spark-ignition gasoline engine

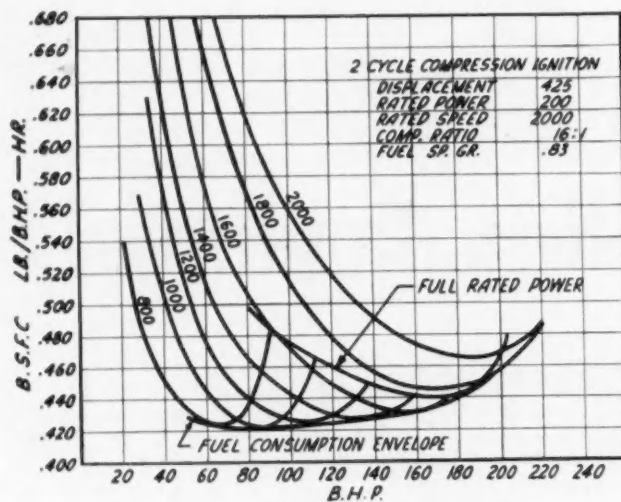


Fig. 3—Typical fuel consumption of a diesel engine

in pounds per bhp-hr and the abscissa is bhp per cubic inch of displacement. Each curve is identified by the type of engine, displacement in cubic inches, and compression ratio.

Here we have two of the most important characteristics of vehicle powerplants—fuel economy, and power per cubic inch—shown in their true relation. Engines represented by the curves are:

- Curve No. 1 is the gasoline engine of Fig. 2, which uses regular grade motor gasoline.
- Curve No. 2 is a very recent automotive engine, designed especially for economical road performance and requiring the best premium fuels on the market.
- Curves Nos. 3, 4, and 5 are from modern four-cycle unsupercharged, four-cycle supercharged, and two-cycle diesel engines, respectively. These are all truck engines using regular commercial diesel fuel.
- Curve No. 6 is from an experimental 181-cu in. passenger car engine designed especially for 100-plus

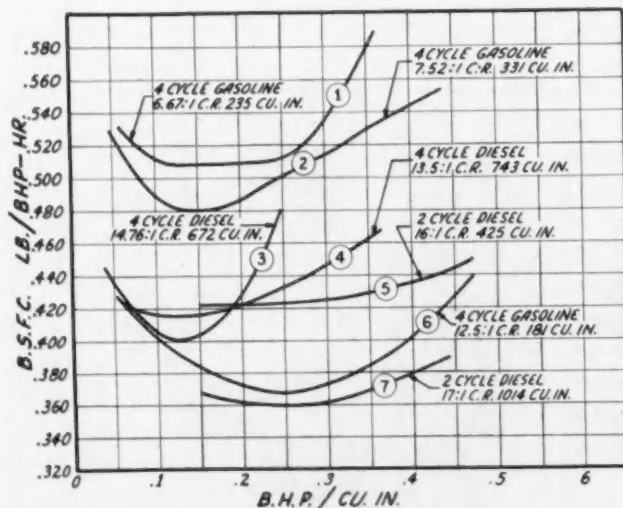


Fig. 4—Minimum fuel consumption envelopes comparing specific fuel consumption versus specific power output of diesel and gasoline engines. Note that in terms of power per pound of fuel, the two-cycle diesel (curve 7) is about 11% more efficient than a 12.5 to 1 compression ratio gasoline engine (curve 6) operating on 100-plus octane number gasoline

octane fuel. It represents the performance to be expected when such fuels and engines are available. The fuel consumption of a larger engine using 100 octane fuel would probably be somewhat higher, due to the lower compression ratio necessary with the larger cylinder.

• Curve No. 7 is from an aircraft-type two-cycle diesel engine and indicates what has already been attained with high output compression-ignition engines.

The gasoline engines all show a rather narrow range of output per cubic inch in which the fuel consumption is low. At high power output, the fuel consumption increases rapidly. This is also true of the unsupercharged four-cycle diesel engine.

But the supercharged four-cycle and the two-cycle diesels both exhibit a very wide range of power where the minimum fuel consumption varies less than 10%. The output of the two-cycle diesel engine per cubic inch of displacement, at rated power, is equal to the top rating of the 12.5 compression ratio, 100-plus octane gasoline engine. In terms of power per pound of fuel, it is almost the same; and in terms of power per gallon, it is at least 11% better, since diesel fuel weighs more per gallon, in the ratio of 8 to 7.

It has already been demonstrated in a number of laboratories that by supercharging, the output per cubic inch of either two- or four-cycle diesel engines can be increased far beyond the above values. There are no apparent limitations to rotational speeds as regards compression ignition and combustion. Commercial limitations are the strength and heat resistance of materials.

But perhaps even more important to the engine user, neither of these increases in output requires any different fuels than those now in use. In fact, the higher the output, the less sensitive the engine is to fuel properties. That is why present-day commercial diesel engines have a considerable advantage in fuel economy and power per cubic inch of displacement over contemporary gasoline engines. This advantage is of such a fundamental nature that there is little probability it will be overcome.

Fuel Consumption Versus Load and Speed

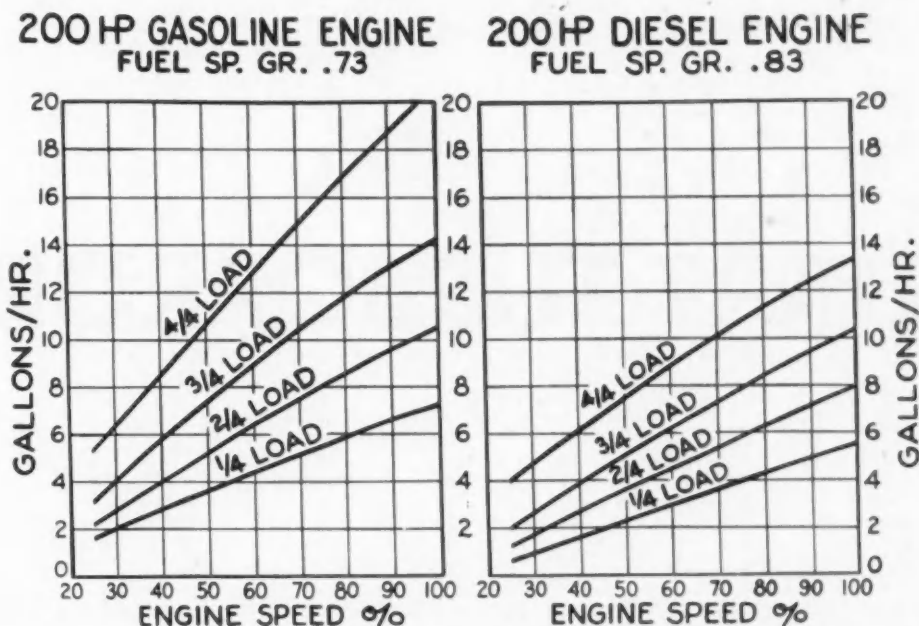
These differences in fuel consumption are shown in pounds per brake horsepower per hour. Since fuel is sold by the gallon, and diesel fuel weighs more than gasoline, let us convert these pounds per horsepower into truck operators gallons.

Fig. 5 shows the performance of two typical 200-hp gasoline and diesel engines based upon the data of Figs. 2 and 3 converted into gallons per hour at various loads and speeds. It has been assumed that the 200-hp gasoline engine would have the same specific performance as the 100-hp engine of Fig. 2. (This is probably a bit optimistic, since the larger engine would probably have a compression ratio of about 5.7 to 1.)

Fig. 6 shows this same data, with the diesel fuel consumption plotted in percent of the gallons used by a similar gasoline engine.

This diagram shows an overall diesel fuel consumption of about 70% of that of gasoline. Many operators report figures of 60% and lower. This may

Fig. 5—Comparison of fuel consumption versus load and speed of a gasoline and diesel engine of equal power output



be accounted for by the use of gasoline engines of lower compression ratio than the 6.67 to 1 quoted, and the almost universal condition of carburetor settings richer than that for best economy.

Any decrease in air density due to temperature, altitude, or air cleaner restriction also tends to enrich the mixture and reduce fuel economy. The properly rated diesel engine always has "air to burn."

These figures show the saving in gallons. This must be multiplied by any difference in fuel cost per gallon to get the true saving. Fuel prices vary from one locality to another and in accordance with petroleum price levels. In the long run, prices must maintain a reasonable relation to production costs.

On this basis, it is reasonable to conclude that diesel fuel will always be cheaper than gasoline by the cost of converting diesel distillate to higher volatility and higher octane gasoline. The difference becomes progressively greater as the octane rating of the gasoline is increased. The lower limit of diesel fuel price is ordinarily the market value of distillates as domestic heating fuel.

This combination of savings in both gallons and cost per gallon in many operations amounts to about 50% of the total gasoline fuel bill. For large trucks covering many thousands of miles per year, this is an important item. As the truck becomes smaller and the mileage shorter, the savings decrease until the advantages of the smaller and cheaper automobile gasoline engines may warrant their use. The point of equality depends upon how small and how cheaply the diesel engine can be produced and upon the price difference in the two fuels. Engine size itself does not alter the fundamental advantages in fuel economy due to the high compression ratios of the compression-ignition engine.

At the present state of engine development, the diesel engine is well ahead in fuel economy and at least equal in power per cubic inch of displacement. Gasoline engines are limited in power and economy by the octane rating of the fuel. Higher octane

means higher priced fuel.

Further improvements in the power and economy of diesel engines are possible with presently available fuels. Diesel fuel is inherently cheaper than gasoline and contains more heat units per gallon.

When the millennium arrives and spark-ignition engines have high octane fuels available at the same price as diesel fuels and can operate at the same compression ratio, the compression-ignition engines will still be ahead in: (1) fuel consumption, by the higher efficiency obtainable at part load with very lean mixtures, and (2) power, by the inherent ability to be supercharged and two-cycled.

(Paper on which this abridgement is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

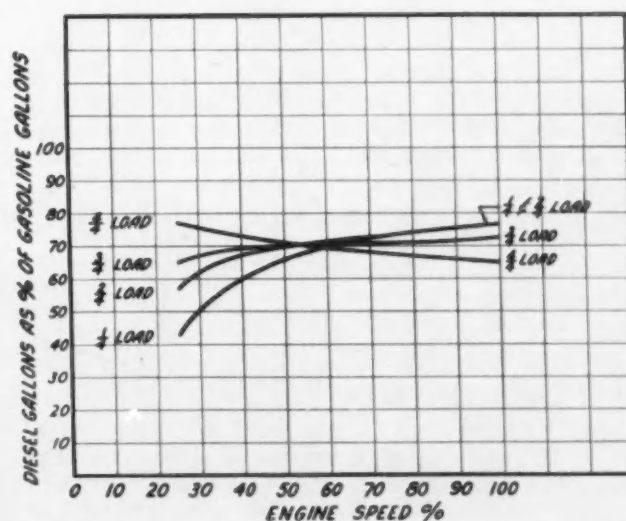


Fig. 6—The diesel fuel consumption data in Fig. 5 are replotted here in terms of percent of gallons used by a similar gasoline engine. The engines compared are both 200-hp truck powerplants

DART TURBOPROP Design

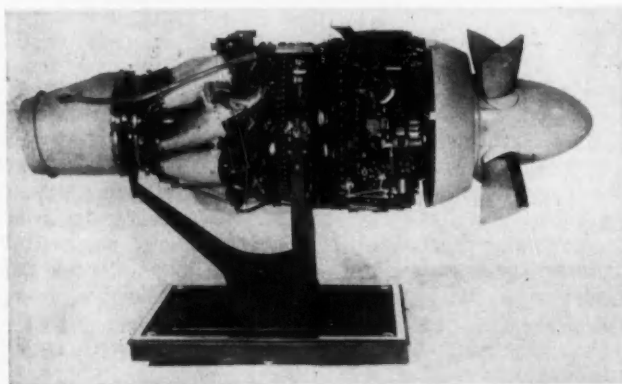


Fig. 1—The Rolls-Royce Dart turboprop is a two-stage centrifugal compressor engine rated at 1400 bhp at sea level. It weighs 993 lb, including oil, oil tank, oil cooler, air intake, nose deicing equipment, and starter. First application of the Dart is to be in the Vickers-Armstrong Viscount airliner

DESIGN steps have been taken to thwart troubles anticipated in the Rolls-Royce Dart turboprop engine, Fig. 1, destined for airline use. Aim is to achieve a 1500-hr life of major engine parts and 500-hr overhaul periods. The trouble list, in order of magnitude, is:

1. Flame tubes and nozzles,
2. Nozzle guide vanes,
3. Turbine blades,
4. Bearings and air seals,
5. Gearing,
6. Making two engines alike.

Flame Tubes

Fig. 2a shows flame tubes from an engine after 400 hr flying. The problem is one of cooling the skin. The tube shown in Fig. 2a has a hot portion between the head and skirt. The general effect of this is cracking and buckling. While similar results are obtained in flight and on the bench, the former appears to be more severe. We have found that

steady running conditions similar to test bench does far less harm to the tubes than the fluctuating conditions of flight.

Essence of long life is to keep the skin temperature down. In designing a tube to run at a lower metal temperature, as shown in Fig. 2b, several conflicting requirements have to be met. No increase in jet pipe temperature must take place, no change to nozzle guide vane temperature traverse—assuming this was correct beforehand, no increase in pressure drop. The skin-cooled tube appears to meet all these conditions, but extended mechanical tests have yet to be made.

Tubes are at present manufactured in Nimonic 75 material and this is still the best we know. In addition to skin temperature control, tests are proceeding with ceramic coatings on the inside of the tube. I am very optimistic that a ceramic protective reflecting layer may open up the possibility later of using a less expensive material, while still further improving the life.

My own objective in this connection is to eliminate the flame tube entirely and to coat the air casing itself with an insulating and/or reflecting material. With afterburning, the gas temperature is some 900 F above that inside the engine and combustion is controlled without any flame tube. Temperature traverse and skin cooling is of course, a problem, but this I think, can be overcome. This futuristic view is, of course, dependent upon meeting all the conditions laid down earlier.

Redesign Curbs Carbon

Flame tube life is also affected by the type of fuel used, by fuel spray unit design and spray cone angle. Our early attempts at endurance running on the Dart produced carbon deposit on the fuel spray units, which we call burners. Carbon formation deflects the spray onto the skin with catastrophic results. In Fig. 3 we show the original burner and the latest development after more than three times the running time. We are now satisfied that we have eliminated the burner problem. Fig. 4 shows the changes we introduced to achieve this result.

Accents Long-Life Features

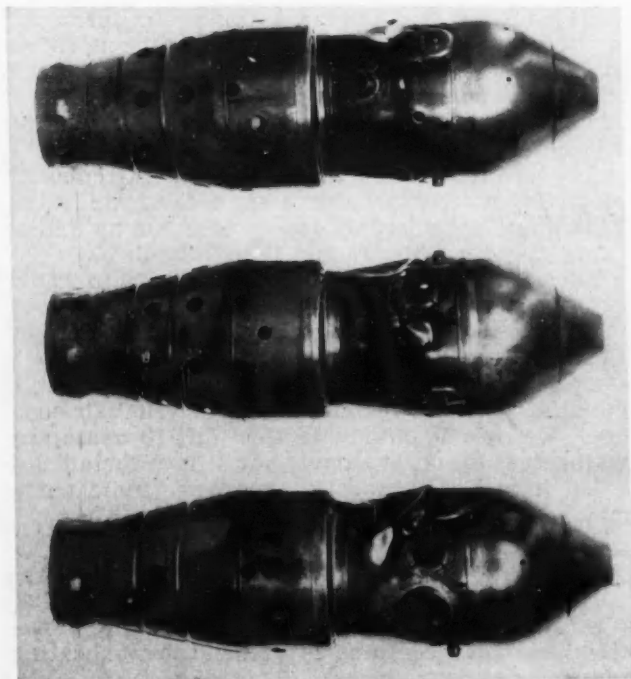
EXCERPTS FROM PAPER* BY

R. N. Dorey, Rolls-Royce Limited

* Paper "Extended Life of Propeller Turbine Engines," was presented at SAE National Aeronautic Meeting (Spring), New York, April 17, 1950.

If leaded fuel is used greater care is necessary in keeping flame tube material at as low a temperature as possible to prevent lead attack. The lower cut fuels of ANA-58 variety also present further difficulties due to aromatic content and carbon formation. We have encountered these problems on other engines and energetic action is underway to overcome them. We do not propose to release the Dart for any other fuel than kerosene.

The operating temperature of the nozzle guide vane is the limiting condition of the engine so far as power and specific consumption are concerned. Effect of flame temperatures on specific consumption is shown in Fig. 5—an increase of say 90 F flame temperature is a prize well worth striving for. Our present limit is 2034 F absolute for take-off, 1890 F absolute for maximum cruise. These figures were established both from running on the Dart engine



A



B

Fig. 2—After 400 hr of flying, the three flame tubes at left showed cracking and buckling between the head and skirt. Skin cooling the flame tube, at right, lowers metal temperature and indicates extended life

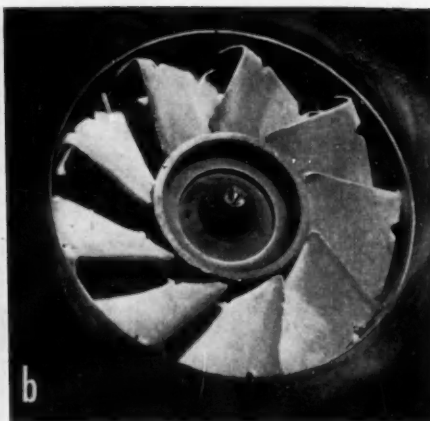
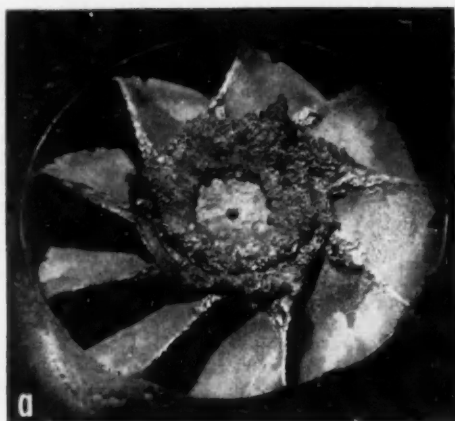


Fig. 3—Note the carbon deposit on the original burner (fuel spray unit) at left in (a) after running only 150 hr. The anticarbon burner at right in (b) ran 500 hr

and using our Derwent experience.

Furthermore, we have established our limiting temperature by running a complete model test at 2105 F absolute and 2034 F absolute for cruise. The nozzle guide vanes were scrap after this test. At 2034 F we have vanes which have completed 900 hours running.

Further development has shown that making nozzle guide vanes hollow, and keeping as nearly as possible to constant metal section, reduces the incidence of cracking and bending due to temperature shock. The next desirable step is to introduce air cooling; but this involves a rather complex problem. Fig. 6 shows the increase in specific consumption and decrease in power due to the use of compressor air for cooling.

With the introduction of nozzle guide vane cooling, some increase in life can be assured at a price. If an acceptable compromise can be established, and this can only be done by operating experience, it may be possible to reduce the metal temperature and

still further increase flame temperature. This would thereby restore specific consumption and improve nozzle guide vane life at a slight cost in bhp.

Plus Values from Cooling

The cooled nozzle guide vane is a project we are actively pursuing, since its application to the prop turbine reacts in the manner described. But on the pure jet, it opens the possibility of increasing the rating as a war time emergency or de-rating the material specification, should the supply of strategic materials become difficult.

Fig. 7 shows the method of introducing cooling air through the hollow nozzle guide vanes.

If air cooling drops the vane temperature by 180 F, which is then restored by increasing jet pipe temperature, the effect is shown on Fig. 5. The increase in life due to lowering the metal temperature is shown on Fig. 8. As regards materials for nozzle guide vanes, Vitallium has given the best results, but supply in Great Britain is difficult. Hastalloy C is showing promise and is almost equal to Vitallium. A good third is H. R. Crown Max, but this suffers from cracking due to temperature shock.

I believe that concurrently with the introduction of cooling we shall be able to use a fabricated vane. This would considerably ease production as well as being cheaper initially and on overhaul.

Experience to date shows that after 800 to 900 hr running, about 5% of the vanes have to be scrapped, mainly due to leading edge cracking. These are all H. R. Crown vanes and not hollow.

As regards nozzles these are now very reliable, manufactured in Nimonic 75 with external air cooling. We do not anticipate this unit to cause any major expense on overhaul; but I have included it as an item since our early experience indicated it may be a high spot.

Turbine Blades

Our present design of turbine blade, Fig. 9, has given excellent results as regards reliability. Failures have been confined to accidental overheating and external damage.

You will notice we use the shrouded type of blade. While in England we have been busy putting shrouds on, you have, I believe, in the United States been

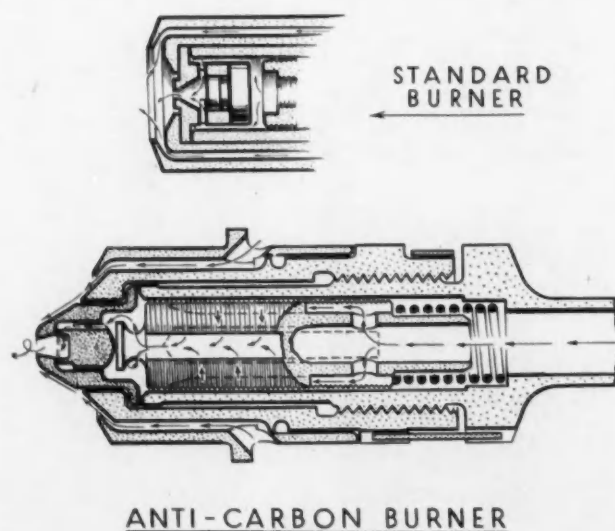


Fig. 4—This is how the standard burner, or fuel spray unit, was modified to prevent carbon formation

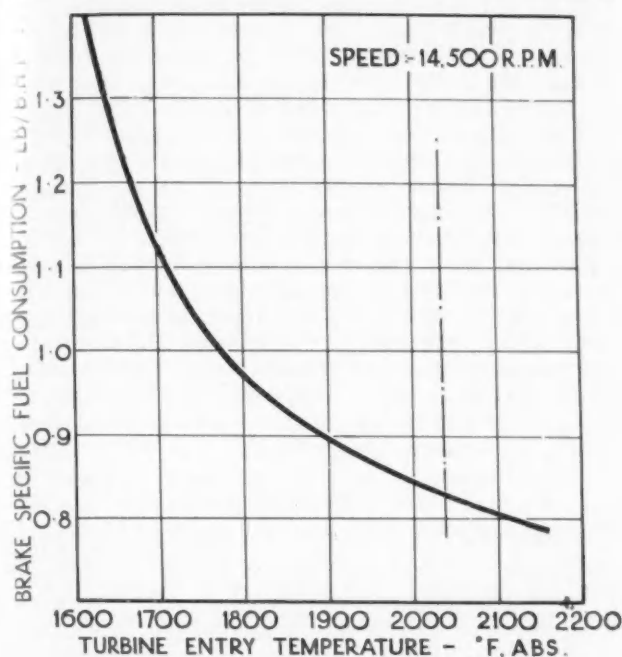


Fig. 5—Effect of engine working temperature on specific fuel consumption

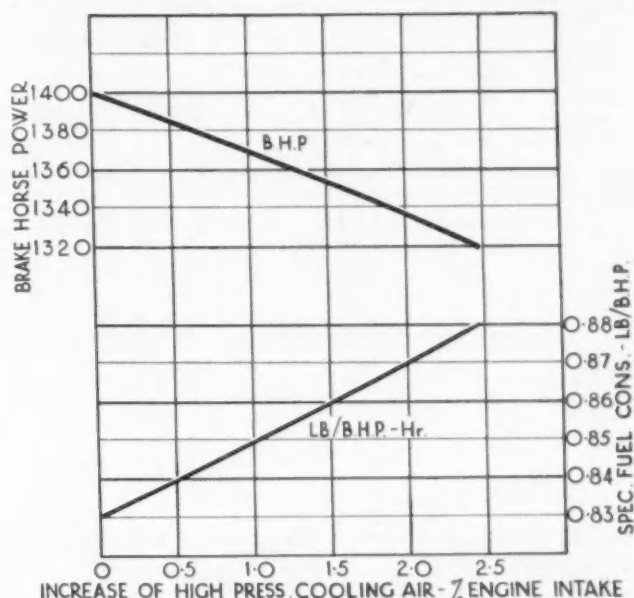


Fig. 6—Effect of an increase in cooling air flow on engine performance

equally busy taking them off.

The vibration characteristics of the blade have been put outside the running range of the engine by shrouding. This in itself is a good reason for adopting them. But we have used them chiefly for performance.

The latest design of blade is shown in Fig. 10, where it will be noted the blade root has been extended. The reason for this is to keep the Nimonic 80A material for the hot part of the turbine and reduce the disc diameter to the point where normal (S62) steel can be used. Nimonic material for turbine discs has been used for some considerable time. Experience has shown us however that apart from its expensiveness, the control of consistent quality has been difficult.

Metallurgically we can set a limit for S62 at 932 F, but in actual practice we shall not exceed 805 to 840 F. This is achieved on the Dart partly by reducing disc diameter and partly by air cooling. Reason for the compromise is to economize as far as possible in the use of compressor air for cooling.

New Blade Cooling Scheme

Having taken this line, the logical step is to use the cooling air to cool the blades. It may not be possible to bring air up inside the disc for strength and/or rigidity considerations; but air can be introduced at the blade root, Fig. 11. While there is no immediate need to take this step, it is only logical to do so when extended life is to be considered.

It may be possible at a later date to use fabricated turbine blades. Our early researches in this direction indicate definite advantages as regards vibration characteristics, but a difficult manufacturing problem from a welding point of view. Such a de-

velopment is worth while, if only to obtain experience on air cooling itself.

The alternative may be a sodium cooled blade, if we can find a suitable material to run with it.

These developments to nozzle guide vane blades and discs will not be applied in our early Dart engines, but they all lead in the direction of improved reliability, improved fuel economy, reduction in overhaul, and initial cost, together with a small reduction in weight. If the prop turbine is to stay in civil use, these features will be introduced as time goes by. Our objective here is to equal, at least at altitude, the overall specific fuel consumption of the

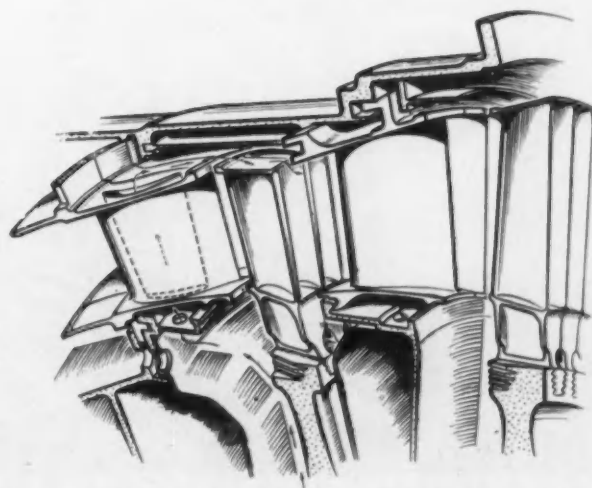


Fig. 7—How cooling air is introduced into the hollow nozzle guide vanes

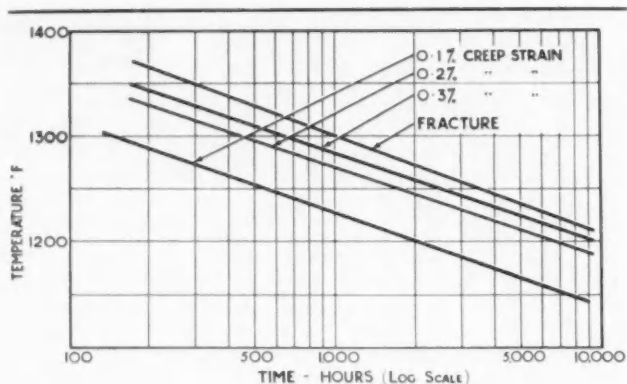


Fig. 8—Effect of temperature on life of turbine blades at constant stress

piston engine, with far better reliability at the same percentage power.

Bearings and Air Seals

The bearing problem in the prop turbine engine may easily be specific to the engine type and therefore some of our experience may not have a general application.

One fundamental we have learned is the need for accurate alignment. Using normal methods in manufacture the out of alignment figure may be around 0.012 to 0.014 in. We have proved quite conclusively that these figures have to be held to 0.002 to 0.004 in. Radial dowelling and accurate machining can give these tolerances without individual unit treatment. Interchangeability can be achieved. If tolerances in excess of the figures mentioned are allowed, bearing and particularly cage wear ensues and also the inherent vibration causes failures of

engine parts, combustion ware in particular.

With good alignment, adequate oiling, slack clearances (of the order of 0.003 to 0.004 in.), adequate ventilation and freedom from hot gases and a conservative loading compared with catalogue figures, our bearing problems have disappeared.

As regards air seals throughout the engine, we believe we know how to make these efficient and reliable. We aim to have the outer static member manufactured in low conductivity material and the inner member in high conducting metal. The aim here is to so arrange the materials that in the event of a rub, the outer member tends to expand away from the rotating part. Controlled thicknesses of the rotating ribs is essential; 0.010-in. thickness is of the correct order. The rotating part must be located radially on the shaft so that expansion can occur, but concentricity is retained.

Gearing

Design and development of a suitable high speed reduction gear for the propeller turbine engine was not, as we had all anticipated, as easy a job as making a reduction gear for an electric motor.

The main problem we came up against was one of high frequency vibration caused by the actual gear teeth on the high speed drive. The frequency was of the order of 5500 cps. Introduction of helical gearing has eliminated the excitation, although the frequency is still there. These high frequency periods caused irritating failures, not only of the gears themselves, but of lock washers, split pins, oil jets, bolts, and studs.

We have had to establish for instance the maximum free length of studs and bolts. To quote one example, a 5/16-in. diameter bolt must not have a free length exceeding 2 in. I realize that a problem such as this is likely to be specific to any particular



Fig. 9—Shrouded turbine blades used on the Dart engine is in keeping with general British practice

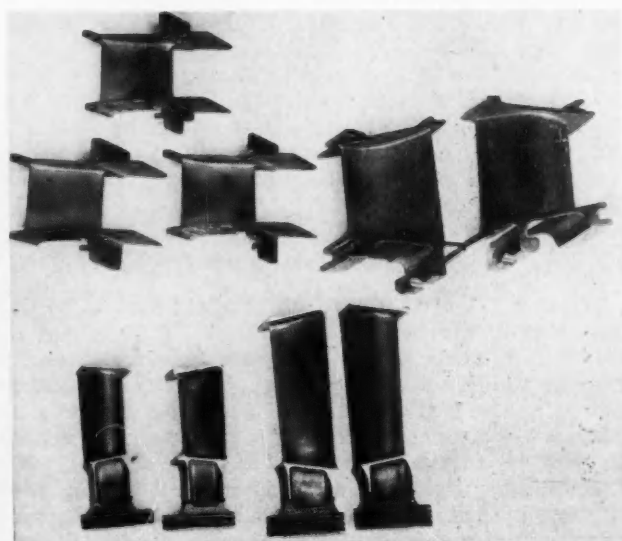


Fig. 10—High and low pressure turbine blades with their respective nozzle guide vanes

engine and note is made of it from an interest point of view.

With adequate lubrication of the bearings, care and attention to the lineability of the gear shafts, we do not anticipate any major problems with reduction gear on the Dart engine. As development proceeds, particularly if in the distant future any increased rating is considered, it may be necessary to add strengthening features from time to time.

The type of gearing we use involves the accurate timing of the three lay shafts. This is achieved by an adjustment of the shafts themselves and in practice has been found to be a simple operation.

The gearing is of course, that part of the engine which determines the type of oil we use. At the present time the specification is D.E.D. 2479. But this lubricant has very definite limitations, particularly as regards cold weather operation. Unlike the piston engine, we are unable to dilute the lubricant under severe cold weather conditions. We have therefore to select an oil which will flow down to the limiting requirements, -40 F, and still retain the lubricating qualities over the whole temperature range.

Various samples of oil with additives have been examined from time to time. But up to the present, we have not found an oil which, while giving high lubricating qualities at the maximum operating conditions of the engine, retains these properties down to the low temperature condition. The curve of low load-carrying capacity is usually such that the lubricating qualities of the treated oil are no better at -40 F than an oil of lighter grade would be on its own.

The claim often made that at 194 F a certain additive doubles or triples lubricating qualities entirely neglects the characteristics of a similar mixture at a low temperature condition. There is a very definite need for a synthetic oil retaining load-carrying capacity over the complete range of temperature conditions. It is essential that any such lubricant retains its lubricating qualities down to the minimum limit, while not approaching the boiling point at extreme heights.

The turbine engine, unlike the piston engine, can be opened up while the oil is still at approximately ambient conditions, and it is essential that the gearing is lubricated correctly.

Making Two Engines Alike

In general it is difficult to ensure that a line of production engines going through a plant will all come out of the door identical. Variations in manufacture are likely to be hidden until the engine is in the operator's hands. I do not think that the propeller turbine engine will differ in this respect from piston engines. Experience has shown us that the maximum amount of attention possible must be paid to this particular aspect of civil engine manufacture.

It will mean that the inspection of processes through which the parts and units have to pass will be considerably more than one would normally use for the production of a wartime engine. These extra precautions however, are absolutely essential if all the engines are to run to their allotted overhaul life. The care naturally starts back in the raw material stage where the laboratory and metallurgical con-

trol, as well as forging technique, has to receive the same minute attention.

It is realized that an unscheduled engine change is worse from an airline point of view than a reduced overhaul period.

Consistent manufacture is mentioned because it is so very important for long life. Once the specification of the engine is settled, the maintenance of a supremely high standard of manufacture is absolutely essential to consistently good results.

(Paper on which this article is based is available in full in multilithographed form from SAE Special Publications Department.) Price: 25¢ to members, 50¢ to nonmembers.)

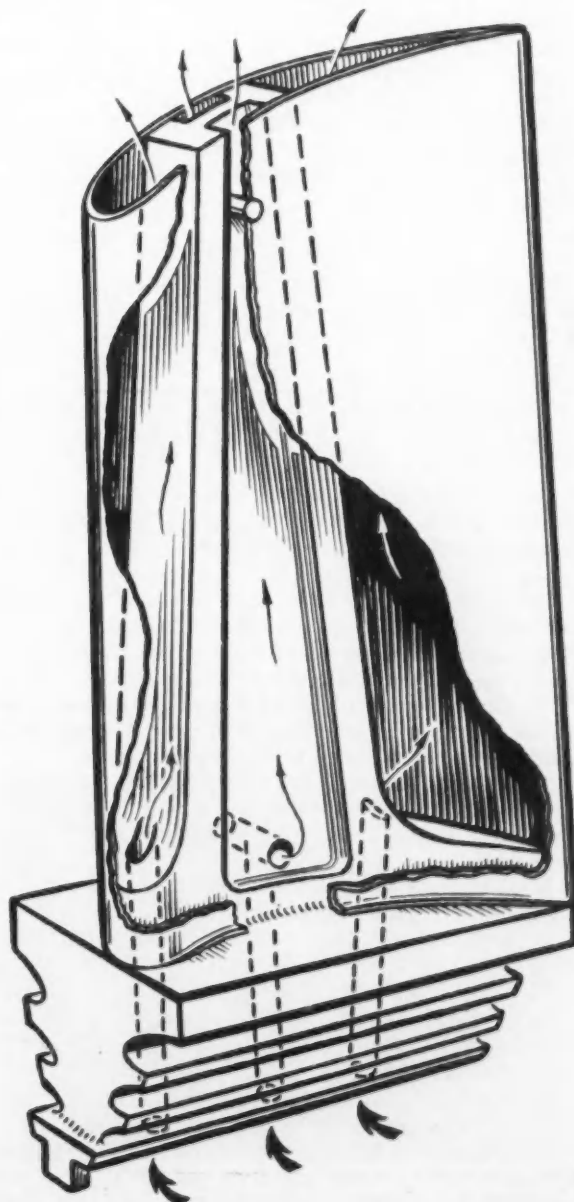


Fig. 11—There is a possibility that air can be brought up through the blade root for cooling

DESIGNERS got plenty of advice—both practical and theoretical—at the SAE National Tractor Meeting at the Hotel Schroeder in Milwaukee, September 12-14.

Users of earthmoving and construction equipment came to the meeting and told the engineers exactly what is happening to their equipment in the field—and made suggestions for improvements. From fellow designers, the technicians got advice about how to go about the whole problem of design—with special emphasis on use of small-scale models and pre-design measuring instruments and possibilities for more effective use of welding potentialities. The farm tractor and implement men got research results and reviews of current practice to guide their future design efforts and argued the relative merits of stampings as compared to forgings and castings.

All were genuinely pleased to learn from Standard of Indiana's Dr. Robert E. Wilson, that plenty of fuel is going to be available for running their vehicles. "Though refinery runs are at all-time high levels," he said, "the domestic output could be increased by about 10% without serious difficulty, and another 10% could be imported." He sees no prospective need for rationing of any oil products short of an all-out war with Russia.

Arctic and Mining Service Tough

Arctic and iron mining requirements for earthmoving and construction equipment were particularly emphasized at the sessions. . . and in great detail. Army winterization problems too, got special attention.

It appears that technical, operating and personnel problems all have to be faced in meeting the Army's winterization criteria that:

Ultimately every piece of equipment must inherently be capable of starting and operating under temperature conditions down to -40F, but that:

Kits may be provided in the temperature range from -40F to -65F.

The major technical problems in Arctic operation, according to Army spokesmen, include:

1. Lubrication of engine gears and bearings. (The lubricant itself may change characteristics, and is hard to distribute to critical points.);
2. Coolant may change its characteristics;
3. The cooling system's job is the reverse of normal. It has to keep the engine warm rather than cold;
4. Gasoline often fails to vaporize;
5. Diesel fuel may fail to flow;
6. Normal cranking systems are totally inadequate;
7. Metals become brittle;
8. Greater spaces are required in designs—to accommodate cold-weather clothing worn by operators and repairmen.

Commercial users cited winterization problems similar to those experienced by the Army. Some iron mining operations, for instance, face operating conditions where temperatures range all the way from -40F to +100F. . . and, at the sub-zero temperatures, frozen surface material to a depth of 5 to 6 ft is frequently encountered by earth-moving machines.

Users' Tractor

There are Arctic operational problems, too, according to discussers. Lowering of personnel efficiency is the greatest. Another: Actual on-the-job efficiency of a piece of construction equipment, even when satisfactory mechanically, is lowered by (1) cold operating conditions and (2) being called upon to do a job more severe than normally encountered because of frozen condition of materials.

Lower personnel efficiency in extreme cold is inevitable. One eminent Arctic explorer was quoted as saying: "There is a 2% loss in efficiency for each degree below 0 F. That would mean a human being has no energy left for useful work at -50 F."

That's why winterization of any type of equipment must take human elements into account to a major extent, it was emphasized. Reaction times and actual energy demands, normal under temperate conditions, cannot even be approached in extreme cold.

Checking low temperature effects on men, it was shown, has brought the term "windchill factor" into common use. This factor is a measure of the rate at which a warm body gives up heat under various combinations of temperature and wind velocity. At 35F with a 45-mph wind, for example, a person gets just as cold as he would at -35F if the wind were only about 1½ mph. At windchill above 1400, flesh will freeze in a few seconds if exposed to the wind . . . and the windchill has exceeded 2400 several times at Fort Churchill, the Corps of Engineers' Hudson Bay proving ground.

Iron mining users were quite specific about *their* experiences and desires as regards equipment—particularly truck equipment. Each of them who spoke agreed that the off-highway truck has come to stay in the tough, rough usage of iron mining—and that use of automatic transmissions is definitely on the rise.

Engine life appears to be increased by use of torque converters chiefly because shock loading and engine lugging tends to be eliminated. They are being specified on many new trucks, it was revealed, as a result of much experimenting by mining companies in the last two years. Few iron mine trucks will be purchased without them in the future, it was freely predicted at one session.

Service Reports Enlighten and Earthmover Designers

Increased engine weights plus converters and their gear boxes, it was admitted, are posing real problems in supporting this package in the truck frame. Following considerable argument about engine supports, one experienced operator opined that the best method is a cradle mounting . . . which he described as one with the flywheel housing bolted to the front of the cradle, the rear of the transmission bolted to the rear of the cradle—and with the cradle mounted to the frame through trunions.

One operator summarized what the iron mining customer today would like in a truck as follows:

1. A unit with a load-carrying capacity of 30 long tons or more . . . driven by spring-mounted tandem axles;
2. A powerplant with about 13 to 15 hp per ton of load;
3. Hydraulic cushioner for the power train;
4. Automatic transmission—or a quick-shift box;
5. If torque converters are used, they must allow the engine to work its maximum hp rating and not lug on the down haul;
6. Transmission should match the converter, so enough gear splits are available to allow the converter to operate at maximum efficiency;
7. Steering systems, hoist systems, and auxiliary apparatus should be designed for long life.

Despite specific suggestions for improvement of trucks and other iron-mining equipment, users at the meeting paid tribute to the consistent improvements already made. Diesel-electric locomotives, trucks, tractors, scrapers, shovels, draglines, wagon-drills, and belt conveyors, they emphasized, all are being used—and all are being constantly improved.

Design Techniques Discussed

Full application of two pre-design techniques was urged during the meeting. Reduced scale models, it was suggested, can save much time and many dollars in the process of designing equipment. Stressed also was the value the many measuring tools available to get predesign data.

A long list of advantages to be gained from using

reduced scale models was compiled from the testimony of a number of engineers given at the meeting. The expense of such models, it was agreed, is negli-

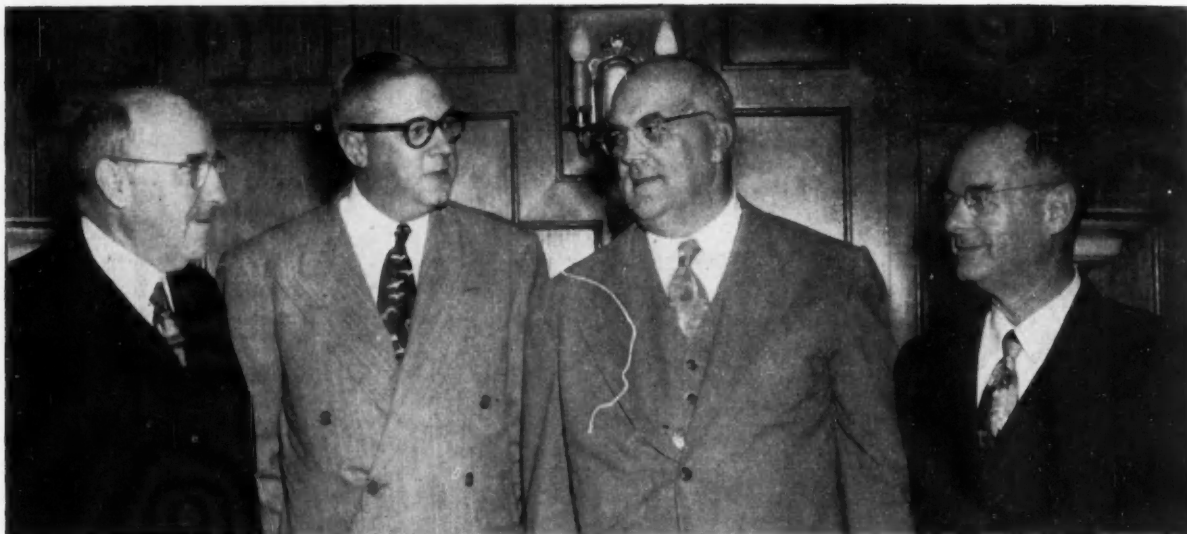
More than 700 engineers assembled in Milwaukee, Sept. 12-14 for SAE's 1950 National Tractor Meeting. No other national gathering better symbolizes the combination of friendship-making, idea-exchanging, and engineering advancement which characterizes SAE meetings in general. It was another in a continuing line of Milwaukee tractor fetes in which success has become a tradition.

Heading the General Committee for this year's meeting was L. S. Pfof—and working with him were SAE Vice-President W. H. Worthington; Tractor Meetings Committee Chairman H. L. Brock; Milwaukee Section Chairman H. M. Wiles; and W. E. Knapp, and Trevor Davidson, vice-chairman of the Tractor Meetings Committee. The Milwaukee Section Reception Committee was headed by H. H. Wakeland.



Left to right: H. M. Wiles, chairman of Milwaukee Section; H. L. Brock, Tractor Meetings Committee chairman; and L. S. Pfof, general chairman of the meeting

The Tractor Dinner



Left to right: Dr. Robert E. Wilson, chief dinner speaker; A. T. Colwell, toastmaster; J. C. Zeder, president of SAE; and W. H. Worthington, 1950 SAE vice-president representing Tractor and Farm Machinery Activity

"I see no prospective need for rationing of any oil products short of an all-out war with Russia," Dr. Robert E. Wilson, chairman of the Board, Standard Oil Co. (Ind.), told the 300 members and guests at the Tractor Dinner which closed the formal meeting on Thursday evening.

The dinner program was opened by SAE Vice-President W. H. Worthington, John Deere Waterloo Tractor Works, who introduced Toastmaster A. T. Colwell, Thompson Products Co. SAE President J. C. Zeder, Chrysler Corp., spoke briefly, emphasizing the importance of the engineering contributions made by SAE members in both war and peace times. He told of arrangements already in the making between SAE and the highest Army echelons by which the Society's technical manpower again is being readied to serve the nation's military needs.

Petroleum Supplies Plentiful

Dr. Wilson, chief speaker of the evening, emphasized the importance of petroleum in our economy by mentioning that, with only 7% of the world's population and land area, this coun-

try produces and uses from 60 to 70% of the world's oil, automobiles, and tractors—or about 30 times as much per capita as the rest of the world. He said that while demand and refinery runs were at all-time high levels, about 65% above 1942, the domestic output could be increased about 10% further without serious difficulty, though at somewhat higher cost, and that another 10% could be imported if needed.

Considering the question of supplies for the more distant future, Dr. Wilson pointed out that there had been recurrent scares about our nation's running out of oil for the last 50 years, but that proven domestic reserves of crude oil had increased almost every year and are now at an all-time high. This year's additions to reserves will probably break all records. However, these increases cannot be expected to continue forever, and looking still farther ahead he anticipated a gradual increase in crude oil imports as our first reliance.

He pointed out that our technology and our free enterprise system are really our great resource, rather than a particular number of barrels of oil in the ground.

gible in comparison with the cost of a full-sized machine, in view of their value in saving of time and clarifying all kinds of unit arrangement problems.

Other advantages cited were:

1. Group discussions are shortened when held around a table on which is a reduced-scale model;
2. Service education programs and sales promotional efforts are helped;
3. Reduced-scale models absorb the attention of listeners in a lecture room between the time one talk ends and another begins;

4. They enable a young engineer to give a senior a clear conception of a new idea—and help the senior to make clear his objections;

5. They cut the time needed to develop a new projection layout to accommodate suggestions involving reallocation of units;

6. They permit ready checking of unit stability, operator visibility, component weights . . . and help on patent investigations.

Wood or plexiglass are the materials most generally used for visual and functional models—and celluloid or brass for stress analysis, it was brought

old. In the latter case, it is possible to measure, not only stress magnitudes, but also their directions, forces, torques, and deflections.

Nearly 20 different kinds of tools of measurement available for pre-design analyses were described and discussed at one session. "In the last decade," one proponent of such tools said, "structural design and its development has become a science. New tools of measurement enable the engineer to build on facts instead of assumptions."

Fatigue testing machines, it was pointed out, produce factual data on a material's resistance to fatigue—and are widely helpful because most machine elements are subject to cyclic loads—and their failures due predominantly to fatigue. Transducers employing wire strain gages, on the other hand, are available to measure force, torque, pressure displacement, and acceleration . . . and bonded wire gages, sensitive to temperature instead of a strain, are also at the engineer's command.

Some of those lauding the value of such measurement tools, claimed that the analytical approach to design has been oversold. . . . that it should be considered as a trial solution—not the solution. "Mathematics, even in the hands of an expert, is not powerful enough to disclose the true stress distribution inherent in most engineering structures," one discussor argued.

Current Practices Evaluated

Current practices in research techniques, in rim widths lug heights of tractor tires, and in farm implement hydraulic controls were evaluated in formal papers and following discussions at several sessions.

Chief debate about research techniques centered around the relative merits of proving ground as against field testing. When the smoke cleared away, most participants seemed to conclude: "There is much to be said on both sides."

One engineer summarized: "It looks to me as though proving ground testing has the greatest number of advantages—but that field testing has the more important ones. . . . Anyhow, it is clear that both types are needed."

Another, who thinks the factor of time should have great emphasis in any such evaluation, said in effect: "Field testing should be limited to jobs that cannot be duplicated in laboratory or proving ground at reasonable cost . . . and all rush jobs certainly should be assigned to the proving ground."

Still another, who leaned in the opposite direction, argued: "No matter how beneficial the proving ground may be, it can't create *all* the test conditions which will develop defects. So, new equipment must get into customer hands for early pre-evaluation."

"The Farmer's Probably Right"

Attempted evaluation of the effect of rim width on performance of farm tractor tires set off more formal session fireworks than any other single item at the meeting. Evaluation of lug height effects caused relatively little disagreement.

Research results were presented which one authority summarized by saying: "These tests indicate

Under the general chairmanship of L. S. Pfost, the following served as chairmen of the six technical sessions of the SAE National Tractor Meeting: A. F. Meyer, Jr., P. J. Sperry, K. L. Magee, H. W. Delzell, W. H. Worthington, and E. W. Tanquary.

This report is based on discussions and ten papers. . . . "Use of Reduced Scale Models in Heavy-Duty Equipment Design," by R. A. Beckwith, Koehring Co.; "Earthmoving Equipment Design from the User's Point of View," by H. E. Farnam, Jr., M. A. Hanna Co.; "Earthmoving Equipment on the Minnesota Iron Ranges," by J. H. Hearing, Jr., Oliver Iron Mining Co.; "Winterization of Construction Equipment," by R. W. Beal, Engineer Research and Development Laboratories, Fort Belvoir; "Proving Ground versus Field Testing," by P. H. Spennetta, Caterpillar Tractor Co.; "The Elements of Metal-Arc Welded Design," by L. C. Bibber, Carnegie-Illinois Steel Corp.; "Welding Design—Resistance Type," by F. A. Bodenheimer, Federal Machine and Welder Co.; "The Effect of Lug Height and of Rim Width on the Performance of Farm Tractor Tires (Partial Report on cooperative research program of U. S. Department of Agriculture and U. S. Rubber Co.), by I. F. Reed, U. S. Department of Agriculture, and J. W. Shields, U. S. Rubber Co.; "Design by Measurement," by W. T. Bean, Jr., Consulting Engineer; "Hydraulic Control Systems for Farm Tractor Implements," by H. A. Ferguson, International Harvester Co.; "Progress Report—Hydraulic Cylinder Standardization," by E. W. Tanquary, chairman, Engineering Advisory Committee, Farm Equipment Institute; and International Harvester Co.

All of these papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in SAE Quarterly Transactions.

that, for practical purposes, application of 11" tires to 9", 10", 11", and 12" rims produced no appreciably different effects on performance in either sand loam or clay."

But both tire and tractor engineers joined the researchers themselves in emphasizing the limitations of the tests results to the particular tire sizes and soil conditions peculiar to the test. Impressed by farmer's demands for wider-than-recommended rims, particularly with the larger sized tires, they chorused a desire for additional data upon which to base future design decisions.

Calls for Industry Action

"Farmers don't spend \$50 to \$75 extra for tire equipment if the benefits they think they are getting aren't real," one engineer said. "We're going to need extremely good proof to convince him he should stick to the now-recommended rim widths. . . . Either the farmer knows something we don't know—and had better find out . . . or we are right and must be able to prove it conclusively."

Then one after another rose to echo these sentiments. All were interested in the specific evaluations presented, but none was willing to let so warm an issue rest only on the coldest possible facts.

More generally accepted were the test data aimed at resulting evaluation of tire lug-height effect on tractor performance. These added up to something like this:

"In loose sand, tires with low lugs ($\frac{1}{2}$ ") perform much better than those with high lugs ($1\frac{3}{4}$ ")—and in loam do a little bit better. But in clay, there isn't much to choose between them."

Continued on Page 78

Advent of Gas

Key Issues

Military-Industry Cooperation To Grow In Planning, Research

The military services' intent of working even closer than ever before with industry, as shown by Air Force Generals Carroll and Johnson, was hailed as good news by engineers and executives alike at the meeting.

Brig.-Gen. A. H. Johnson, chief of the Air Materiel Commands industrial planning division, said the aeronautical industry today is the backbone of military mobilization planning. (See p. 23 for excerpts from Gen. Johnson's talk.) Maj.-Gen. F. O. Carroll, Commanding General of the Air Engineering Development Division, revealed that the Arnold Engineering Development Center, now under construction at Tullahoma, Tenn., is a tool for industry and government alike.

So that the research center will operate for the common good, the Air Force has set up an advisory board, consisting of engineering executives from industry and educators, to give counsel as to policies and operations. A private organization, under contract to the Air Force, will manage and operate the Arnold Engineering Development Center.

Among the test units planned for the Center are:

1. High-Altitude Engine Test Facility—for testing turbojets and ramjets under simulated flight conditions of speed and altitude.
2. Gas Dynamics Facility—for development testing models of aircraft and guided missiles through the supersonic and hypersonic speed ranges. It will permit a Mach number range of 1.2 to more than 5.
3. Propulsion Wind Tunnel—for testing powerplant installations in both the transonic and supersonic ranges.

PLEASE for safer, more regular airline operations shared top billing with revelations of new gas turbine advances at the SAE National Aeronautic Meeting, at the Biltmore Hotel, Los Angeles, Sept. 28-30.

More than 500 attended the technical sessions and the dinner and aircraft engineering display set new records for the Meeting. Twenty five exhibitors added to the technical fare with currently developed engines, propellers, and accessories.

Airline operators and Government regulating agencies forecast growth of air travel at an accelerated pace, and, with it, a perhaps tougher-to-handle air commerce. Gas turbine makers, hopeful of speeding adoption of their engines in air transport, revealed emergence of a second stage in turboprop and turbojet development. Now that engineers have established a technology for designing and building the basic engine, they are striving for greater economy, reliability, and icing resistance by modifying the fundamental configuration.

Big concern of airline operators, said many at the meeting, is the ability to absorb a progressively larger share of the travel business safely.

Air travel statistics coincide with the growth trend indicated by the 1950 census. The census shows that large places are getting larger, that small communities changed little. Bulk of air traffic increase in recent years also has been in metropolitan districts, and traffic flow growth has been largely confined to between communities already getting most of the business.

New York Port Authority forecasts that in 1980, more than 39 million passengers will be carried by air lines, compared to the less than 15 million carried in 1949. Plane cargo is expected to increase from about 169,000 tons to one and one-half million tons over the same period.

Safety figures, showing a continually bettering picture, could take a reverse trend in the light of these growth statistics, some warned, unless safety is vigilantly advanced by operators, manufacturers, and Government agencies.

Air carrier operations to date show good progress in safety, according to figures quoted. From 15 passenger fatalities per 100,000,000 passenger miles in

Turbine and Safety Among Aero Men

General Chairman R. C. Stunkel (second from left) greets military guests (left to right) Maj.-Gen. F. O. Carroll, Rear Admiral A. C. Miles, and Brig.-Gen. A. H. Johnson



1930, the rate has steadily decreased to 1.3 in 1949.

Although pilot error receives the blame for 60 to 70% of air carrier accidents, aircraft designers and airline operators were warned not to be complacent. Improvement of the pilot's environment, controls, and navigation aids will greatly reduce this error, argued a researcher in aviation safety.

In a straight-from-the-shoulder discussion session, operators told manufacturers what they want to raise their operating safety level. Both sides came away with clearer concepts of what each can do in enhancing safety from standpoint of the airplane, the atmosphere, and the pilot.

Fatigue Life Critical

Focusing on the airplane, engineers accented structural fatigue as a big safety factor. Some argued that the search for strength in materials, aimed at weight saving, at the expense of endurance limit, portends disaster from premature fatigue failure. Note was made of extensive research under NACA aegis for a method that tells how near a material is to fatigue failure, at any period of service.

One approach to the fatigue problem suggested is the setting of a useful life period for items such as airplanes and engines, after which the unit would be junked. This was rejected on two counts: First, economics—not safety—is involved in aircraft engines. Overhauled engines with replaced parts are considered to be as good as new. And it's easy to inspect engine parts for defects. Second, too little is known about fatigue of airframes, and no inspection method yet devised determines how far along a part is in its fatigue life.

Aircraft and engine men warned operators that failures in some components may stem from over-maintenance. A telephone company experience is a case in point. The telephone system suffered less operating trouble *during* a maintenance men's strike, than *before* it. Inspection and cleaning wore out relays faster than normal operation.

Biggest item in the powerplant package needing research is the propeller, opined one engineer. He said icing, de-icing, automatic feathering, and propeller braking are still far-from-settled items. The transition to turboprop engines in no way diminishes these problems. In fact, turbine engines—both propeller and jet types—will hatch differ-



The meeting program was developed under the aegis of (left to right): W. W. Davies, chairman of sessions on air transport's future; T. T. Neill, Aircraft Activity meetings chairman; O. E. Kirchner, Air Transport Activity meetings chairman; and G. W. Newton, Aircraft Powerplant Activity meetings chairman.

ent and more serious problems as regards both the powerplant itself and aircraft operating characteristics.

Pros and Cons of Accelerated Tests

The much-debated accelerated service test, designed to ferret out and rectify failures before a new aircraft carries passengers, inspired spirited controversy.

Some felt that the 700 hr such an airplane flies before reaching commercial service (400 hr testing

by design firm, 150 hr by CAA, and 150 hr by airline) is adequate. They felt it should uncover the types of error or failure causing serious accidents. Others said that isn't enough. They believe it takes much more time to bring to light and remedy failures. They advocated several courses—longer period for prototype development, freight-carrying service prior to passenger-carrying, and break-in of a new airplane in the Military Air Transport Service.

A new concept of structural integrity bounced on engineers at the meeting left them with much food for thought. Here it is:

a. Wings. Wings should be designed to resist any type of failure. (A back-room cynic said it is impossible to design a wing that some pilot cannot pull off if he wants to.)

b. Cockpit. It must be independent of the rest of the airplane, not subject to explosive decompression. It must maintain its pressure at altitude, regardless of cabin pressure.

c. Cabin. It should be free from explosive decompression possibilities; resist tears or holes in fuselage; be separated at propeller plane into two pressure compartments, one on either side of it.

d. Functions. Propeller failure must not be allowed to damage the flight control system, engine control system, electrical equipment, and other such important units. All these systems should be carried in a steel duct under the cabin floor, shielding them from flying propeller blades. Some labelled this a "rubber glove for leaking fountain pen" philosophy. Better fix the propeller so it won't fly apart, they advised.

Safety Versus Economics

A brief flare-up over safety versus economics between regulatory officials and operating engineers revealed identical objectives, but different emphasis. One side had it that safety alone should be sufficient incentive for advances such as reverse-pitch propellers. The other saw no reason for not exploiting improvements economically as well. "Although a perfect safety record is commendable, an airline has to operate to achieve it," argued an air transport man.

Meeting discussions also mapped current and pro-

Under the general chairmanship of R. C. Stunkel, the following served as chairmen of the seven technical sessions of the SAE National Aeronautic Meeting: Jerome Lederer, J. E. DeRemer, Donald Douglas, Jr., J. W. Young, W. W. Davies, A. E. Raymond, and Rear-Adm. A. C. Miles.

This report is based on discussions and 14 papers "Safety in Performance Operating Rules," by R. B. Maloy; Civil Aeronautics Administration; "Research and Development to Promote Safety in Aviation," by T. P. Wright, Cornell University; "Development of the Anti-Icing System for the J47 Gas Turbine," by N. F. Frischhertz and B. E. Morrell, General Electric Co.; "Gas Turbine Anti-Icing Tests at Mt. Washington, New Hampshire," by P. M. Bartlett, Bureau of Aeronautics, and T. A. Dickey, Naval Air Material Center; "Why Patents?" by W. R. Lane, Patent Counsel, North American Aviation, Inc.; "Factory Personnel Problems (Human Factors for Maximum Producibility)" by L. O. Stockford and K. R. Kunze, Lockheed Aircraft Corp.; "Comparison of Turbine-Propeller Engines with Various Cycle Arrangements for Subsonic Flight Speeds," by T. F. Nagey, National Advisory Committee for Aeronautics; "Design and Operation of Gas Turbine Propellers," by R. C. Treseder and D. D. Bowie, Aeroproducts Division, General Motor Corp.; "Turboprop Installation Problems," by F. H. Sharp, Consolidated Vultee Aircraft Corp.; "Air Transportation and What is the Technical Future," by K. R. Ferguson, vice-president, Northwest Airlines, Inc.; "Air Transportation and What is the Technical Future," by E. C. Wells, vice-president, Boeing Airplane Co., presented by Maynard L. Pennell, chief of preliminary Design Unit, Boeing Airplane Co.; "Air Transportation and What is the General Future," by F. B. Lee, deputy administrator for Program Planning, Civil Aeronautics Administration; "Industrial Mobilization in the Aircraft Industry," by Brig.-Gen. A. H. Johnson, chief, Industrial Planning Division, Air Materiel Command; and "Arnold Engineering Development Center," by Major-Gen. F. O. Carroll, USAF, commanding general, Air Engineering Development Division.

All of these papers will appear in abridged or digest form in forthcoming issue of SAE Journal, and those approved by Readers Committees will be printed in SAE Quarterly Transactions.

used programs for safety through control of the atmosphere. Flying safety in bad weather depends chiefly on electronic air navigation aids. According to one report, the Instrument Landing System (ILS), just one of several devices being perfected, already has considerably improved service and safety.

A CAA engineer advised that the Government recognizes its obligation of creating an air navigation program to simplify air navigation for all-weather operations and to eliminate significant schedule delays. Limitations of the old air route system, built around a four-course radio range, are being overcome, he said. About 400 very-high-frequency, omni-directional ranges are being installed to provide multiple air routes.

CAA also in embarking on an extensive radar installation program at major traffic concentrations, an official of the agency announced. These installations are expected to handle all air traffic forecast for 1955 with added safety and decreased delay.

Making the pilot's life an easier one will also enhance flying safety, operating men felt. Discussions showed that shaping the cockpit to both the limitations and aptitudes of the pilot, as a human being, is receiving growing attention as an engineering responsibility. More functional instrument dial display, more distinct control knob shape, and cockpit standardization are but a few of the directions in which research is moving to cut down accidents from "pilot error."

Talk of projected programs brought into open discussion the big thought in most every operator's mind: When are we going to switch from reciprocating to turbine power, and in which direction will we move—turbojet or turboprop?

An aircraft man predicted emergence of a practical transport airplane within the next five years, flying at close to Mach 1. It will fly nonstop transatlantic flights and carry reasonable payloads, he said. Of course the turbine will have to take over from the piston engine to bring such new performance levels. But, he warned, engineers will have to unburden these powerplants of cumbersome controls and complications before airlines will take gas turbines into their family.

Prop or Jet for Turbines

General agreement on the inevitability of turbine power replacing reciprocating power gave way to split opinion on the shape the gas turbine will take. Turbojet advocates argued that freedom from propeller problems holds much attraction, all things being equal. But they admitted that the turboprop shouldn't be ruled out if it offers greater fuel economy.

Turboprop adherents counterpunched with this thought: Combining the gas turbine, with its light weight, with the variable pitch propeller, with its high propulsive efficiency, can give aircraft the power increase necessary for high-speed flight. Main reason for turbojet inefficiency, they claimed, is its inherently poor propulsive efficiency, rather than either compressor or turbine inefficiencies.

Both sides were pacified by an aeronautical researcher's analysis. It showed the turboprop engine is more efficient at a 30,000-ft altitude at flight speeds up to 400 mph. The engines are competitive

at speeds between 400 and 500 mph. The turbojet surpasses the turboprop at speeds above 500 mph in the comparison made by this man.

Continued development of each was urged, with selection for any particular application based on simplicity versus fuel economy.

Control Complexity Decried

Bright future of both these powerplants can be quickly dimmed by complicated and/or unreliable controls, engine men were warned. The trend toward ever-increasing control complexity continues unabated. Unless it is checked, we may soon have a four-year course in controls leading to a degree of "Doctor of Controls."

"I don't mean that automatic controls never should be used," said an aircraft builder. "But if a manual control can satisfactorily perform a necessary function, be not led astray by some minor advantage offered by automatic controls. And if the function itself is superfluous, let's not put it in control."

Another commentary on control complications brought approving nods from most: Complexity denotes ignorance; simplicity signifies knowledge.

Advent of turbine-powered airliners will call for new requirements in Civil Air Regulations. Aircraft and airline men learned that CAA officials already are attuned to the difference between reciprocating and turbine power, and the changes needed.

For example, with current four-engine aircraft, the one-engine-out requirement holds for field length at take-off and flight path. The one-engine-inoperative field length may be okay for turboprop aircraft, ventured a CAA engineer, but for the turbojet aircraft, the all-engine take-off distance and flight path may be critical.

Something Old in Something New

Switch in meeting emphasis from operations to design showed gas turbine engineers to be up against some of the old piston engine problems masquerad-



R. D. Kelly (left), SAE Vice-President for Air Transport Activity, and H. D. Hoekstra, SAE Vice-President for Aircraft Activity



25 Manufacturers Show at Aircraft Engineering Display

The following companies exhibited their products at the meeting:

Aeroproducts Division, GMC
Aeroquip Corp.
AiResearch Mfg. Co.
Angle Computer Division, S and
D Engineering Corp.
Axelson Mfg. Co.
Barber-Colman Co.
Bobrick Mfg. Co.
Chiksan Co.
Cleveland Pneumatic Tool Co.

Fafnir Bearing Co.
Hi-Shear Rivet Tool Co.
Hydro-Aire, Inc.
Jack & Heintz Precision Industries, Inc.
Kelite Products, Inc.
Lear, Inc.
Minneapolis-Honeywell Regulator Co.
Pacific Airmotive Corp.

Pacific Scientific Co.
Ryan Aeronautical Co.
Scintilla Magneto Division, Bendix Aviation Corp.
Solar Aircraft Co.
Stratos Corp.
Vickers, Inc.
Western Gear Works
Westinghouse Air Brake Co.

ing in new clothes. Fuel economy rears its challenging head, but calls for a different approach. Ice can continue to wreak havoc, but now the engine rather than the propeller is the victim. And propeller engineers still find themselves unsnarling troubles, only propellers now must absorb greater shaft horsepower.

Turbine engines, like their piston forerunners, are not escaping the typical discontent of engineers with their achievements. Already engineers are seeking ways to squeeze more power, higher efficiencies from turboprop engines. Analysis by NACA researchers show that adding another turbine to the basic cycle, using turbine exhaust gases to heat compressor air, and a combination of these two offer attractive fuel savings under certain conditions.

The investigation proved the regenerative-plus-reheat turboprop engine, at sea level, decreased specific fuel consumption as follows: 2% lower than the reheat engine; 6% lower than the regenerative engine; and 10% lower than the basic engine. At 30,000-ft altitude, the figures on fuel consumption reduction are 4, 5, and 7%, respectively.

The turboprop engine with 100% reheat between the two turbines increased airplane range 10% at low speeds and about 15 to 20% at higher flight speeds. The regeneration turboprop, with a 0.5 regenerative effectiveness, increased the basic engine's range about 3% at both low and higher flight speeds. The combustion reheat-regenerative turboprop did

slightly better on range than the improvement produced by the reheat engine.

Ice is making things hot for gas turbine engineers, engine men admitted. The natural icing conditions throughout most of the year at Mount Washington, New Hampshire, have made it an ideal research center and proving ground for icing on jet engines.

Gas turbine anti-icing has progressed in two ways from the Air Force-Navy sponsored Project Summit on Mount Washington. First, engineers have learned the effect of ice accumulations on turbine engines. Second, they have developed effective anti-icing measures.

Biggest threat gas turbines face from atmospheric icing is choked off air flow through the engine. Tests from the joint research project show that each 1% loss in inlet total pressure reduces by 2% the thrust of a typical turbojet engine.

Aside from thrust loss, ice formation can be equally damaging by increasing cycle temperature for fixed-area nozzle-type engines, demonstrated several Naval engineers. The pilot finds that temperature of the combustion chamber or tailpipe increases. Since icing also lowers thrust or power in flight, only way to maintain equilibrium flight conditions is to increase rpm's. But since the tailpipe temperature rise dictates a reduction in engine rpm that further cuts down power, the pilot finds himself in an untenable position.

Mount Washington icing tests showed turbine

temperature rise to be a most simple and direct indicator of icing intensity. The tests also showed that some icing conditions do not seriously detract from engine performance. Pressure losses in the inlet depend not only on icing intensity, but also on ice formation character.

Typical of specific designs growing out of the Mount Washington researches is a hot-air anti-icing system for the J47 turbojet engine. It has transformed the J47 from a fair-weather to an all-weather powerplant, claimed several meeting participants.

With this system, each engine inlet component susceptible to icing is individually protected. Included are the inlet screen, inlet guide vanes, island fairings, forward frame struts, and accessory section nose cowl.

Tests of the system both in flight and on Mount Washington showed the engine now can shed accumulated ice satisfactorily, even at idle speed. The system prevents ice formation on protected engine portions at high power.

Main difference between our old propeller design problems and those today with turbines, said several specialists in this field, is that engines now put out more than twice as much power. Turboprops producing 5500 shaft horsepower are not unusual. This power increase can boost airplane performance 0.5 to 0.2 Mach numbers, if the propeller design is right.

Propeller men said their chief aerodynamic problem is to extend the propeller's high efficiency at subsonic Mach numbers into the high subsonic and transonic region. Reducing blade section thickness, they found, best maintains high efficiency at high Mach numbers.

Single rotation propellers can efficiently convert increased turbine power with suitable blade diameter increase. But that's only if diameter limitations, imposed by the airplane, are not too severe. Dual rotation propellers show up to advantage where these powers must be used within limited propeller diameter.

Turbine engines impart lower torsional stresses in propellers than reciprocating engines, it was pointed out. But that doesn't mean turbine propellers can be built lighter. Turbine propeller forces being met with today's high-speed aircraft still require about the same weight.

Turbine Installation Challenging

Reminiscent of piston engines too, said an aircraft man, is the turboprop-to-airframe matching job. While selection criteria are much the same, installation problems do differ.

Here are some of the things we ask ourselves, continued this airframe engineer: Should we use two turbines of 10,000 hp each or 10 turbines at 2000 hp each? Do we want high power at all times, or just for take-off, and good cruise economy at other times? With the engine selected, what is the best nacelle configuration?

Also important is the turbine's service record . . . its reliability, actual specific fuel consumption, life between overhauls, the damage it will withstand. The engine should have enough drive pads of the size and gear ratio to mount generators, alternators,

pumps, and blowers to handle airplane systems.

A particularly acute installation problem with the turboprop-powered Convair seaplane is with control systems. The high-frequency vibration set up by the powerplant—while not of large amplitude—causes electrical equipment to fail in fatigue. New type specifications for control mechanism components were suggested.

Patents and Personnel

In addition to problems specific to the aeronautic industry, design and production engineer each heard about items that cut across all of industry. The designer took away clearer conceptions of engineer-company relationship with regard to patents. Production men gained an insight into factory worker behavior from a study of the influence of age.

A patent counsel advised that large companies are keenly aware of the need for improved relationships between the employing company and its employee engineer or inventor. "However," he remarked to an engineer who felt there are some basic inequities, "if you hired and paid a carpenter to build a house for you, to whom would the house belong after it was completed?"

Another big flaw in the patent set-up decried by inventors is that the courts are invalidating 85% of patents coming before them. That's why patent owners are reluctant to sue for patent rights. Their patents may be invalidated. They claim this makes powerful manufacturers feel free to infringe patent rights of individuals. If the trend continues, some feel attorneys will advise their clients not to disclose their inventions.

All agreed the patent system needs clarification. It requires better examination at the U. S. Patent Office and a clear, consistent treatment of patents by the courts.

Age Makes a Difference

Lockheed Aircraft Corp.'s personnel study of 365 women factory employees showed some relationship between age and attitude toward both working conditions and supervision. But industrial personnel researchers warned against developing pat solutions from such limited studies, for influencing human behavior.

To questions of what each employee liked best about Lockheed working conditions, older women reacted to technical-mechanical aspects; the younger ones to their associates. Older women also are more apt to complain about inadequate air conditioning, toilet conditions, and noise and confusion.

Interpretation of this is less than simple, it was pointed out. Some might say that as people grow older, they become increasingly aware of toilet conditions. Others might argue that the older women were conditioned in a social period stressing fastidiousness more than today.

Attitude-toward-supervision studies also showed the difference in values held by older and younger women. The older women were more responsive to the supervisor's administrative performance, his technical competence. Younger women were more impressed with his personal relations—cheerfulness, attentiveness, and friendliness. These results were seen as helpful in supervisory training.

CRC

Activity Swings

THERE has been a marked change during the past year in the general outlook of Coordinating Research Council activity, which has been accelerated during the past few months. This change is the increasing emphasis on military projects, a reversal of the trend which had been evidenced since the end of World War II.

During World War II, something better than 90% of CRC work was being carried on for the military services. This decreased after the end of the war to approximately 50% in 1947, approximately 39% in 1948, and to approximately 35% in 1949. However, this trend has been abruptly reversed. At present, a little better than 50% of the CRC projects are either carried on at the express request of the military services, or are projects in which the military services have evidenced interest to the extent of being willing to support a portion of the cost.

The ability of the CRC to follow trends of this type with a minimum amount of disturbance in its technical committees is a tribute to its post war planning. It has put CRC in the position of being able to operate very closely with the military services when this is necessary.

The trend to concentration of CRC activity on a smaller number of projects, in which there is a definite interest by the cooperating industries and the military services, is continuing. At present, work is being actively carried on by CRC committees on 40 active projects. Eight projects were initiated during the past year, and one of these has been discontinued. Of the remaining 33 projects, 19 were initiated more than two years ago. During the past year, 15 projects have been completed.

CRC technical reports prepared during the progress of work, or upon completion of a project, are released by the appropriate CRC Committee to the sustaining members for publication or general distribution. An arrangement has been made with SAE for distribution of released reports through its Special Publications Department, and lists of all available CRC reports are published periodically in the SAE Journal.

Fuel and Equipment Research

The interest in aviation fuel and equipment problems, which had been gradually decreasing, is now

increasing, and represents approximately 30% of the cooperative effort of the fuel and equipment problems in CRC. The interest in motor fuel and diesel fuel problems is continuing, but significant is the marked increase of interest on the part of the military services in these two fields.

The Motor Fuels Division has completed the project covering an investigation of the effect of sulfur in motor fuels on engine condition. This project was the most extensive which has been carried out by the CRC. Papers on this report were presented to the American Petroleum Institute and to SAE. Reports indicate that the CRC work on this project has become a milestone in the study of sulfur in motor fuels.

The program of the MFD Road Test Group has covered a study of the various road testing techniques preparatory to the investigation of the effect of individual variables of engine design, fuels, and operating conditions on octane number requirement for passenger cars. It is expected that during the next year specific studies of some of these variables will be undertaken. In addition, the Road Test Exchange Program, which has proved so useful to the cooperating laboratories in improving the accuracy of road testing techniques, will be continued.

Car Octane Needs Surveyed

A survey of octane number requirements of post war passenger cars has been carried out, with specific attention being given to those cars which were designed for use with premium quality fuel. A paper on this work will be presented this month at the SAE National Fuels and Lubricants Meeting. In addition, another survey has been made covering the octane number requirements of passenger cars which have been adjusted according to the manufacturer's recommendations, both in clean condition and after engine deposits have been accumulated. Information obtained from this standard equipment survey covers 95% of the passenger car makes which are being operated.

During the present year, octane number requirements of commercial vehicles will be obtained to supplement the somewhat limited information already available from individual company surveys. In addition octane number requirements of a num-

Back to Military Problems

ber of Ordnance vehicles will be obtained this fall.

The Equipment Survey Group has recommended that an extensive over-all survey of the octane number requirements of passenger cars be made every three years, and that specific surveys be made during the intervening years.

The Diesel Fuels Division is still carrying out the full-scale field service tests on railroads to insure that the widest possible range of diesel fuels is available for railroad services. The general category of fuels being tested covers fuels containing approximately 1% of sulfur, and cetane number of approximately 40. The one-year test program on the Gulf, Mobile, and Ohio Railroad, and a short term test on the Baltimore and Ohio Railroad have been completed. The Great Northern Railway test will be completed early this fall. Tests will be initiated in September on engines manufactured by two additional companies.

The Diesel Fuels Division has completed a study of methods of estimating the ASTM cetane number. A report was presented to the American Petroleum Institute discussing the limitations of the various methods and recommending the use of a "CFR Calculated Cetane Index," which is more accurate than other systems being currently used.

The Diesel Fuels Division had drawn up a tentative program for conducting a field test to study the effect of sulfur in diesel fuel on engine condition. Representatives of the equipment manufacturers indicated, however, that in view of the inconclusive nature of the previous laboratory work on this subject, it would be undesirable to embark on an expensive field test until more definite and conclusive laboratory information is available. Accordingly a new laboratory test program is being developed.

At the request of the Diesel Fuels Division, the U. S. Bureau of Mines is continuing laboratory testing in a constant volume combustion bomb. A series of fuels will be tested at varying temperatures and pressures to obtain basic information on the combustion process. This work will be continued during the coming year under the joint sponsorship of the American Petroleum Institute and the Internal Combustion Engine Institute.

The Aviation Fuels Division project on the vapor-lock problem of gas turbine fuels and fuel systems

is continuing. A report on the first phase of this work has been transmitted to the U. S. Navy, Bureau of Aeronautics, which is supporting the project. Additional testing, including the evaluation of fuels on which service information will be obtained, is now under way.

The project on pumpability of gas turbine fuels at low temperature is being reactivated. The first phase of the work on this problem was completed about one year ago, and as a result of this work a supplementary program, calling for a variation of the test technique and inclusion of additional fuels, was indicated. Negotiations are currently under way to have this work supported by the Air Force. Laboratory bench tests are also being studied as a possible means of evaluating this low-temperature pumpability problem.

At the request of the military services, two additional projects have been initiated during the year. The first is a study of the combustion characteristics of gas turbine fuels, dealing primarily with the fundamental aspects of combustion, as measured by such parameters as flame speed and quenching distance. The second is a project covering various small-scale gas turbine combustors to provide a mechanism for cooperative interchange of rating data on fuels on which full-scale engine experience is available.

In the reciprocating engine field, the CFR Aviation Fuels Division is continuing its problem of the study of deposits in the induction system of aircraft engines. Cooperative tests on two fuels, on which service information is available, have been completed, and a search is continuing for additional fuels on which service information may be available.

Lubricant and Equipment Research

The Coordinating Lubricant and Equipment Research Committee activities have also been affected by the increased attention being evidenced by the military services.

The cold weather project being carried on for the Ordnance Department will be continued this year.

The program on studying the lubrication requirements of Ordnance vehicles which was initiated last year will continue. An extensive test program covering service testing of special reference lubricants

containing high percentages of additives were carried out at two Ordnance arsenals to determine whether there would be any detrimental effects from the use of these lubricants in gasoline engines. Tests were carried out on a number of stationary engines at the Aberdeen Proving Ground. An Ordnance convoy composed of a number of types of heavy duty vehicles operating in desert and mountainous country was tested out of a West Coast Arsenal. Additional testing with other special test lubricants will be carried out during the coming year.

One of the problems that has been worked on during this year has been the development of techniques for obtaining in the laboratory the same type of engine deposits on the piston skirt and in the crankcase that occur in actual service. Considerable progress has been made and special piston-ring combinations are being made available to the cooperating laboratories to bring about these deposits.

At the request of the Air Materiel Command, an extensive project has been initiated with the primary purpose of assisting the Air Force on the problem of the mutual adaptation of airframe lubricants and equipment. The program of the Airframe Lubricants Group is designed to assess the lubricant requirements of the various mechanisms built into the aircraft design and to enable changes to be made by each industry to obtain the best over-all effective-

ness. An important phase of this project is the work of the Service Evaluation Panels. These Panels have the responsibility of obtaining actual service experience and requirement data for the Group and of carrying out service test programs as they are required.

Another phase of this project is a study of various methods by which the development of improved bearings and improved lubricants for aircraft powerplant use might be accelerated. This work is being carried on for the Air Force and the Navy. The main rotor bearing problem of the gas turbine is an excellent example of where cooperative work may result in improvements and the first attention of the Group is being placed on this problem.

A study of the long-time storage of automotive and aircraft engines is being carried out at the request of the Office of the Chief of Ordnance. This project has called for inspections of large amounts of equipment stored at Ordnance, Air Force, and Navy bases. As a result of the recommendations of this Group, extensive rehabilitation programs have been initiated by the military services. This work is continuing with attention being given to other factors such as fuel and cooling systems, power train items, and so forth. This problem is of course receiving a great deal of attention from the military services because of the "demothballing" program now being undertaken.

Users' Service Reports

Continued from Page 69

The give and take on hydraulic control systems for farm tractor implements took on more the aspect of a review than an evaluation. The four basic systems currently in use were noted as (1) nudging, (2) modified nudging, (3) automatic draft, and (4) follow up. Each of these—or some variation of them—was shown to be flexible enough to cover a majority of required applications.

Further development was predicted as new problems demand more ingenuity from engineers. "The accomplishments attained today," one speaker summarized, "are only an introduction to the work which is yet to be done in the field of hydraulic controls for farm implements."

Supplementing this review of current practice, was an interesting progress report on hydraulic cylinder standardization work which has been going on under Farm Equipment Institute auspices.

At one session, the engineers reaped a wealth of specific design-useful information about metal-arc and resistance types of welding.

It was brought out that both types of welding have very wide areas of application—and that knowledge of welding potentials can help the designer to better

performance of his functions. Good and bad examples of design practices were brought out.

Production flavoring for the meeting was provided by a panel discussion debate about the possibilities of stampings to replace forgings and castings.

One speaker detailed specific cases, including a tractor fender bracket, where substitution of stampings for forgings resulted in stronger and better design as well as substantial cost reduction. Another emphasized similar possibilities in substitution of light stampings for malleable castings on such a typical implement part as a mower guard. Potential betterments by use of heavy stampings were also explored at the session—as were problems and procedures involved in cold impact steel extrusion and copper brazing.

Tool equipment, dies, fixtures, and design techniques peculiar to steel stampings also got a thorough going over. While agreeing about the difficulty of making direct comparisons, most discussers seemed to agree that careful study of original design and proper technique will often produce a stamped or fabricated part which is clearer in appearance, stronger and better from a functional standpoint than the normally-used castings.

BY-LAW CHANGES

The following changes* in By-Laws were made by the SAE Council at its meeting of September 14, 1950, to become effective immediately:

- B38** Professional Activity Committees shall consist of not less than twelve nor more than sixteen voting members of the Society. ~~Such committees shall have not less than twelve members,~~ including the Chairman.

In the inaugural year of each Professional Activity, the members of its committee and the Chairman of the committee shall be appointed by the Council. Thereafter, the Chairman of the committee shall be the Vice-President representing the Activity, who shall, with the approval of the Council, appoint the members of the committee, including ~~the Vice Chairman~~ a Vice-Chairman for Meetings and a Vice-Chairman for Membership. The Chairman may designate any member of the Society as a consultant of the committee. In his absence, the Chairman shall appoint, to serve in his place, either the Meetings or Membership Vice-Chairman, as he may select.

The functions of a Professional Activity Committee ~~is~~ are (a) to represent and act for members of the Society interested in the Activity, by advising with the Council, and with Standing Committees ~~and the Technical Board~~ with regard to the work of ~~the latter~~ such committees pertaining to the Activity concerned; (b) subject to review and approval by the Meetings Committee, to procure professional papers for, and to arrange, such technical programs at meetings of the Society as are participated in by the particular Activity; and (c) subject to review and approval of the Executive Committee of the Membership Committee, to carry on membership increase work,

- B22** (first sentence, first paragraph)—The Meetings Committee shall be composed of five members to be appointed by the President with the approval of the Council; ~~the chairmen of the Meetings Committees~~ the Vice-Chairmen for Meetings of the Professional Activities; and a Section representative to be appointed by the Chairman of the Sections Committee.

- B23** (first sentence, first paragraph)—The Membership Committee shall consist of five members-at-large to be appointed by the President with Council approval, and ~~the chairmen of the Professional Activity Membership Committees~~ the Vice-Chairmen for Membership of the Professional Activities and the Chairmen of the Membership Committees of the Sections of the Society.

- B39** Strike out Section B39, having to do with the Activity Meetings Committees, and Section B40, having to do with the Activity Membership Committees.
- B40**

*Note: Words underscored have been inserted.
Words crossed out have been deleted.

Test of Bonded Bi-Metallic Piston

Based on paper by

CHARLES E. STEVENS, JR.

Chicago Railway Equipment Co.

THE problem of making a bonded bi-metallic piston, or aluminum piston having a ferrous member cast and bonded in place to receive one or more ring grooves (Fig. 1), has been one of developing a technique which would permit the casting after pouring to attain room temperature without bond failure.

A solution to this problem has been reached by using high nickel cast irons having a high coefficient of expansion, and with this accomplished a piston so produced has been given severe road tests in a diesel engine.

Comparison of an all-aluminum piston (Fig. 2—left), after 23,000 miles of service, with a bonded bi-metallic piston (Fig. 2—right), subsequently installed in the same diesel engine and run 147,000 miles, shows that ring groove wear is greatly reduced by use of a ferrous insert. Assuming that the original machining was to maximum tolerance, the increase in the width of the top ring groove of the aluminum piston was 0.036 in., wear in the second ring groove was 0.006 in., while the

third groove showed slight wear. In the case of the bonded bi-metallic piston there was no positive evidence of wear, even in the top ring groove.

Hardness graphs indicate no adverse effect upon the aluminum structure due to the presence of the ferrous insert.

A photomicrograph of the intermolecular bond of the bonded bi-metallic piston shows this bond maintaining its continuity after the 147,000 miles of service. Some surface evidence of bond separation is indicated, but full sectioning reveals the bond to be uniformly continuous along the bottom and inner radius of the insert and around the full 360 deg of the piston. The spotty indications of bond discontinuity were all at the top interface and extended no great depth. (Paper "Bi-Metallic Pistons," was presented at SAE National West Coast Meeting, Los Angeles, Aug. 14, 1950. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

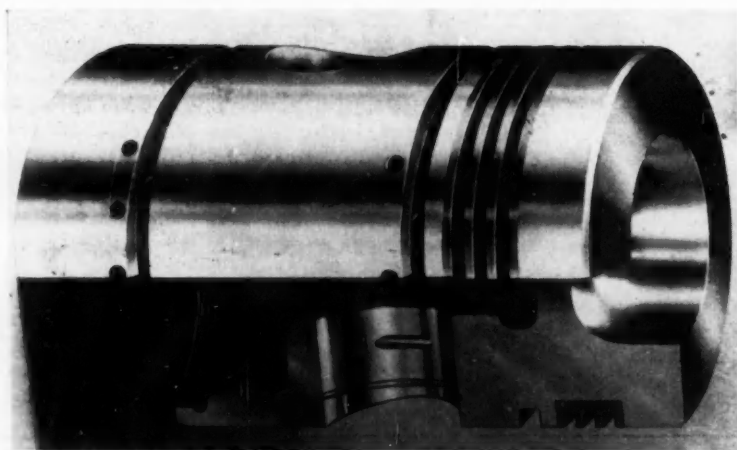


Fig. 1—A bonded bi-metallic piston, now used in a diesel-powered bus, cut away to show ferrous insert

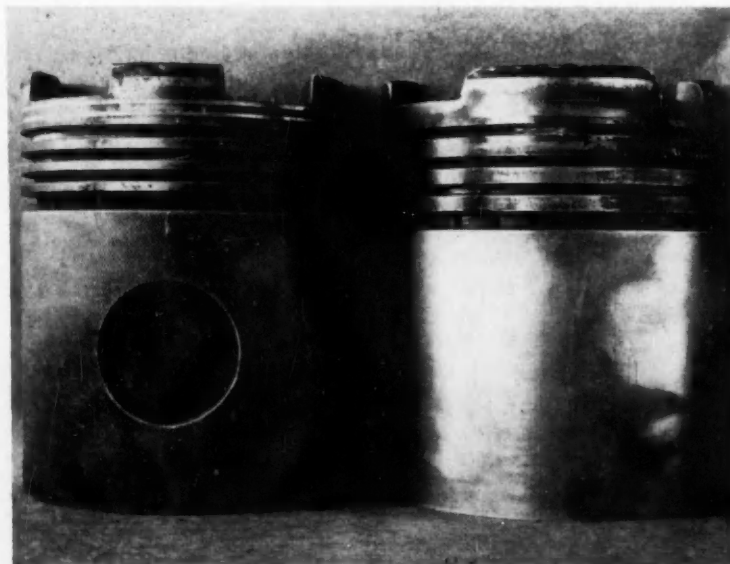


Fig. 2—Wear comparison between an all-aluminum piston (left) after 23,000 miles of service and a bonded bi-metallic piston (right) after 147,000 miles. Both pistons were used in the same diesel engine

Effect of Fast Flight On Turbojet Design

Based on paper by

W. V. HURLEY

General Electric Co

STUDY of the high speed band of the engine design field reveals the nacelle drag to be a large percentage of the engine thrust, and, although not so obvious, the airflow per unit frontal area is also important.

The design pressure ratio has a fairly large effect on the airflow per unit frontal area of the engine. An engine having a high mass flow single stage of axial compression would entail

Continued on Page 106

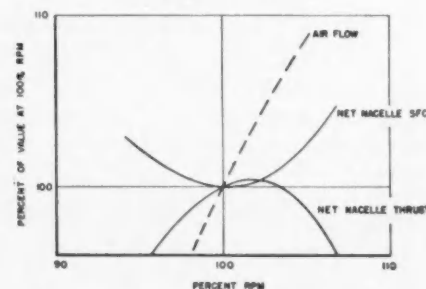


Fig. 1—This chart of optimum rpm determination for a turbojet, at a Mach number of 1.6, shows how the airflow rises as the rpm is increased, while the allowable turbine temperature drops, due to the rise in stress

CALENDAR

Atlanta Group—Nov. 20

Town House, 110 Forsyth St.; dinner 7:00 p.m. Meeting 8:00 p.m. New Jet Aircraft and Related Subjects—Prof. A. Y. Pope, assistant professor, aeronautical engineering, Georgia School of Technology.

British Columbia—Nov. 7 and Dec. 4

Nov. 7—Hotel Georgia, Vancouver, B. C., Canada; dinner 6:30 p.m. Meeting 7:45 p.m. The New JBS Diesel and DD Fuel Pump—Harold Hall, general service manager, Cummins Engine Co.

Dec. 4—Hotel Georgia, Vancouver, B. C., Canada; dinner 6:30 p.m. Topic to be announced. Speaker: R. M. Riblet, chief engineer, automotive division, Timken Roller Bearing Co.

Buffalo—Nov. 21

Hotel Sheraton; dinner 6:30 p.m. Meeting 8:00 p.m. High Speed Aircraft—Robert Stanley, president, Stanley Aviation Corp.

Chicago—Dec. 5

Hotel Knickerbocker, Grand Ballroom, Chicago, Ill.; dinner 6:45 p.m. Meeting 8:00 p.m. Jet Engines—Comparison of progress in Europe and America—Frank C. Mock, manager, fuel feed engineering, Bendix Products Division. Social Half-Hour. Sponsor(s) to be announced.

Chicago (South Bend Division)—

Nov. 20

Hotel LaSalle, Bronzewood Room, South Bend, Ind.; dinner 6:45 p.m. Meeting 8:00 p.m. (Panel Session) Statistical Quality Control. Speakers: J. A. MacLean (Panel Leader), quality manager, Bendix Products Division; J. V. McHugh, quality control engineer, Bendix Products Division; R. E. Rhoades, quality control analyst, Bendix Products Division, and J. F. Gyoles, quality control analyst, Bendix Products Division.

Cincinnati—Nov. 27

Engineering Society Headquarters; dinner 6:30 p.m. Meeting 8:00 p.m. Diesel Engine Trends—Lou A. Steele, manager sales, tractors and trucks, Detroit Diesel Engine Division, General Motors Corp., Detroit, Mich.

Cleveland—Nov. 13

Cleveland Graphite Bronze Co.; dinner 6:30 p.m. Meeting 7:45 p.m. Symposium on Hydraulic Valve Lifters—C. W. Truxell, Jr., director of engineering, Diesel Equipment Division, GMC,

and Vincent Young, chief engineer, Wilcox Rich Division, Eaton Mfg. Co. Speaker-Sponsor: Philip B. Rockwood.

Colorado Group—Nov. 14

Nov. 14—Future Developments in Fuels—A. C. Pilger, Jr., engineer in charge of automotive field research, Tide Water Associated Oil Co.

Central Illinois—Nov. 20

Hotel Jefferson; dinner 6:30 p.m. Meeting 7:45 p.m. Clutches, Now and Tomorrow—Harold Nutt, vice-president in charge of engineering, Borg and Beck, Division, Borg-Warner Corp.

Dayton—Nov. 7

Wright-Patterson Air Force Base, Dayton, Ohio Power Plant Laboratory Inspection Trip 8:00 p.m. Power Plant Laboratory Chief is Col. M. C. Demler. Group will observe the testing and running of reciprocating and gas turbine engines.

Metropolitan—Dec. 7

Brass Rail, 521 Fifth Ave., New York City; dinner 6:30 p.m. Meeting 8:00 p.m. Styling—Raymond Loewy, Raymond Loewy Associates.

Northern California—Nov. 20

Engineers Club, San Francisco, Calif.; dinner 6:30 p.m. Meeting 7:30 p.m. Speaker and subject to be announced.

Oregon—Nov. 17

Norse Hall, 111 N.E. 11th, Portland,

Ore.; dinner 7:00 p.m. Harold H. Hall, general service manager, Cummins Engine Co.

St. Louis—Nov. 14

Hotel Congress, 275 N. Union; dinner 6:30 p.m. Meeting 8:00 p.m. Present Day Use of Helicopters—C. R. Wood, Jr., manager of helicopter contracts, McDonnell Aircraft Corp.

Southern New England—Nov. 9

Hotel Sheraton, Springfield, Mass.; dinner 6:30 p.m. Meeting 8:00 p.m. Diesel Entry in 500 Mile Race—J. C. Miller, manager of research and refinement, Cummins Engine Co.

Spokane-Intermountain—Nov. 29

Spokane Hotel; dinner 6:30 p.m. Meeting 8:00 p.m. Topic to be announced. Speaker: R. M. Riblet, chief engineer, automotive division, Timken Roller Bearing Co.

Syracuse—Nov. 16

Cornell University, Engineering Campus, Ithaca, N. Y. Dinner at 6:15 p.m. in Willard Straight Hall. Meeting at 8:00 p.m. in Room B. Olin Hall. Some Interesting Cooling Problems in Aircraft Engines—Earle Ryder, engineering consultant, Pratt-Whitney Aircraft Division, United Aircraft Corp.

Texas—Nov. 14

Dallas, Tex. Presidential Meeting, 8:00 p.m.

Twin City—Nov. 8

Dinner 6:30 p.m. Meeting 8:00 p.m. Standardization—Cyril Ainsworth, technical director and assistant secretary, American Standards Association.

Wichita—Nov. 16

Droll's Grill, Wichita, Kans.; dinner 6:30 p.m. Meeting 8:00 p.m. Flying the B-47—D. Heimberger, flight testing division, Boeing Aircraft Co.

NATIONAL MEETINGS

MEETING	DATE	HOTEL
FUELS and LUBRICANTS	Nov. 9-10	Mayo Tulsa, Oklahoma
	•	
	1951	
ANNUAL MEETING and Engineering Display	Jan. 8-12	Book-Cadillac, Detroit
PASSENGER CAR, BODY, and MATERIALS	March 6-8	Book-Cadillac, Detroit
AERONAUTIC and AIRCRAFT Engine Display	April 16-18	Statler, New York City
SUMMER	June 3-8	French Lick Springs Hotel, French Lick, Ind.



CHARLES W. FRICK has been appointed works manager of the Propeller Division of the Curtiss-Wright Corp., Caldwell, N. J. Frick played a prominent part in gearing the automotive industry for peak production during World War II with Chrysler, Willys Overland and Continental. Following the war, he was chief manufacturing engineer of the Shaw Box Crane Division of Manning, Maxwell and Moore. Immediately prior to joining Curtiss-Wright, he was affiliated with the Ford Motor Car Co. and the Kaiser-Frazer organization.



LEE C. DANIELS, formerly chief engineer for the Towmotor Co., Cleveland, Ohio, manufacturers of Fork Lift Trucks, Tractors and Power Trucks, has joined the Buda Co., Harvey, Ill., as vice-president in charge of Material Handling Division.



CLAYTON B. SEYMOUR, formerly associated with the Mall Tool Co., has recently affiliated with The Buda Co., Harvey, Ill. He is manager of engineering in the Material Handling Division. Seymour is currently reception chairman of the SAE Chicago Section.



CARLTON L. ZINK is now connected with Deere and Co., Moline, Ill., as staff member in the product research department. Prior to this, he was manager of the Farm Tire Division, engineering department, Firestone Tire and Rubber Co., Akron, Ohio.

ERIC A. MEYER is now associated with the Worthington Pump and Machinery Corp., Harrison, N. J., as experimental engineer in research and development.

HUBERT STANLEY PHELAN has joined AiResearch Mfg. Co. as assistant to project design supervisor, engineering department. He was formerly in the engineering division of Chrysler Corp. as project engineer in design.

ARTHUR G. WESTLUND was appointed sales manager, Fisk-Gillette Tires Division of the U. S. Rubber Co., on September 27. Prior to this he had been serving as assistant sales manager of Fisk-Gillette Tires.

ADOLPH H. MEYERS has joined the M. W. Kellogg Co. as a mechanical engineer.

FRANK N. PRICE, JR. is now employed by Safeway Stores, Inc. in Denver, Colorado.

EDWARD C. ("TED") WELLS' book "Scientific Sailboat Racing" has just been published by Dodd, Mead & Co. Two sections on care and use of hull, rigging, and sails brim with specific tips for small-boat sailors, particularly Snipe enthusiasts. A third section, with 51 diagrams, explains Wells' racing tactics. Wells has proved in practice that he knows sailing; he took time out from his duties as Boeing's vice-president for engineering to win the United States Snipe Class Championship in 1947 and 1949 and between-times the World's Championship races at Geneva, Switzerland.

Price of the book is \$4.00, and proceeds go to the Snipe Class International Racing Association.

About

CALVIN BRESSLER is now with Bell Aircraft as a designer in the rocket group. He was formerly a design engineer at Cummins Engineering Co., Columbus, Ind.

WARREN H. FARR, Vice-President in charge of manufacturing of the Budd Co. for the past four years and one of the pioneer production men in the automotive industry, resigned on January 1st. However, Farr will continue as a member of Budd's Board of Directors and will act as a consultant to E. G. Budd, Jr. Farr is a veteran of 23 years with the Budd organizations.

THOMAS BARISH, consulting engineer, is moving his offices from Washington to Cleveland. In present activity as consulting engineer he is engaged primarily upon ball and roller bearings, gearings and gear applications, aircraft propellers, wind tunnels, and also theoretical and practical machine design. Barish has addressed National and Section meetings of the SAE, on the subject of ball bearings.

WILLIAM R. CISNEY is now special sales representative of the Tire Valve Division, Bridgeport Brass Co.

P. RIBANYI is now with the Elliott Co. in Jeannette, Pa. Prior to this he was transportation engineer at the Baldwin Locomotive Works, Eddystone, Pa.

S. M. GAMSU has been elected vice-president in charge of engineering for the McCauley Corp., Dayton, Ohio. He has been chief engineer of this company for the past five years.

ALFRED R. PUCCINELLI is now assistant project engineer with Edo Aircraft Corp. of College Point, N. Y. He was formerly senior aircraft engineer at the Atlantic Division, engineering department of Pan American Airways.



Members

F. VAN WORMER WALSH, JR., has joined the M. W. Kellogg Co. of Jersey City, N. J., as project engineer on rocket engine development programs.

GEORGE L. HARTLEY is now general sales manager with Breen Motors, Ltd., Winnipeg, Manitoba, Canada. He was formerly general manager of Acme Motors, Ltd., in that same city.

RALPH M. McCUGH, who, prior to this, was design engineer with General Electric Co., Richland, Wash., is now a graduate student in industrial engineering and an assistant in the mechanical engineering department at Washington University, St. Louis, Mo.

PHILIP A. SIDELL, formerly chief engineer with the Gale Products Division of the Outboard Marine & Mfg. Co., Galesburg, Ill., is now in charge of the development of new products at Qualitrol Corp., East Rochester, N. Y.

SAMUEL J. ZIEGLER, USN (Ret.), has been appointed eastern engineering representative by the Solar Aircraft Co., San Diego, Calif. He will have headquarters at the company's Washington, D. C. office.

ROBERT H. WILKE, previously research engineer with the Harley-Davidson Motor Co., Milwaukee, Wis., is now employed by the Allison Division, GMC, Indianapolis, Ind., as a detail engineer. His new position entails the testing of jet engines, turbo-prop engines and related equipment.

G. RUSSELL NOBLE, who has been project engineer and consultant for some three years with Frank Mayer & Associates, Los Angeles, Calif., has been appointed administrative engineer. As such he will coordinate project activities and be responsible for client-personnel relationships in the field. In addition, he will be available for consultation on specialized design problems.

LEONARD A. STEWART has been appointed staff consulting engineer with Motor Products Corp., Detroit, Mich. He is a graduate mechanical and industrial engineer, and during the past three years he has been chief engineer of the American Coach and Body Co. of Cleveland. In the preceding eight-year period, he was chief body engineer with the Mack Truck Co. of Allentown, Pa., responsible for new products, experimental development covering body sheet metal design, and consultant on chassis design.

LESTER J. HENDERSON, formerly general sales manager of Aeroquip Corp., Jackson, Mich., is now sales manager in the aviation department of The Weatherhead Co., Cleveland, Ohio. He is in charge of all aviation products. Henderson has been chairman of SAE Committee A-3, Aircraft Values, Fittings, and Flexible Hose Assemblies, for the past 10 years.

E. CLAUDE JETER has been appointed manager of Ford Motor Co.'s new production foundry in Cleveland.

Distinguished service citations were awarded to three SAE members at the 11th anniversary meeting of Automobile Old Timers on October 18. They were **CHARLES E. WILSON**, president of General Motors Corp., who was guest of honor; **CHARLES STEWART MOTT**, dean of the board of directors, General Motors Corp., and **FREDERICK E. MOSKOVICS**, A. O. Smith Corp. **CHARLES E. WILSON** received two other important awards last month. On October 3 he was honored at a dinner sponsored by the Automotive Division of the National Conference of Christians and Jews, where he was given an award for "distinguished services in the field of human relations. The American Society for Metals gave him its 1950 Medal for the Advancement of Research on October 26 during the 32nd Annual National Metal Congress and Exposition in Chicago. Wilson was the eighth distinguished scientist-industrialist to receive this honor. The award was established in 1943 to recognize the industrial executive who over a period

EARL BARTHOLOMEW, general manager of Ethyl Corp.'s research laboratories, at right, conducted a series of road test demonstrations late in September for industry engineers showing the advantages of present-day gasoline over the fuels of 1925. The tests, using a 1950 car and a 1921 model touring car, showed that 2 gal of 1950 gasoline are the equivalent of 3 gal of 1925 gasoline. Bartholomew is shown checking the miles-per-gallon reading on the 1921 car.





HANSON ROBINSON, JR., has been appointed transportation manager of Minute Maid Corp., with headquarters in Plymouth, Fla. Previously, he was with White Motor Co., Cleveland, Ohio, as production manager.



ROBERT F. LYBECK recently received two important honors. He was presented with a 30-year service award from the Esso Standard Oil Co., Boston, Mass., and on June 17 he received the Tufts College Distinguished Service Award for outstanding and meritorious service to the college. Lybeck was born in Worcester, Mass., and received his B.S. from Tufts College in 1915 and his M.S. in 1918. He first joined Esso in 1920 as a chemical engineer at the Everett, Mass., Refinery. Having advanced through various technical and sales positions, he is now manager of aviation sales in the New England Division.

of years has consistently sponsored metallurgical research or development, and has helped to advance the arts and sciences related to metals.

WALLACE HALLAM, formerly district manager of the Mack-International Motor Truck Corp., is now with the Hallam-Klein Chevrolet Co. in Greensburg, Pa. Hallam was chairman of SAE Pittsburgh Section in 1947-48.

B. R. TERE, N. Y. Air Brake Co., was chairman of an Aircraft session at the recent National Conference on Industrial Hydraulics, at which SAE Past-President **R. J. S. PIGOTT** was one of the speakers. Tere is present chairman of SAE Committee A-6, Aircraft Hydraulic and Pneumatic Equipment.

JOHN G. WOOD, who recently retired from General Motors Corp., has been appointed a member of the Conservation Planning Board of the National Security Resources Board. At the time of his retirement, he was executive assistant to the general manager of GMC's Chevrolet Motor Division. Wood was SAE Vice-President representing Passenger Car Activity in 1939.

JUD PURVIS, technical editor, Motor Service Magazine, is the author of the recently published book, "Automatic Transmissions Simplified." Written for mechanics and car owners, the book explains the operation and construction of Hudson's Drive-Master, Hydramatic, the Chrysler transmissions, Dynaflo, Powerglide, Ultramatic, and the Studebaker Automatic Drive. So that these drives will be easy to understand, simple explanations of fluid couplings, torque con-

verters, planetary gears, and other automatic transmission parts are given. Each drive description also includes a section on trouble shooting. This 264-page book is available for \$4.00 per copy from the publisher, The Goodheart-Willcox Co., Inc., Chicago.

JOSEPH GILBERT, associate editor of SAE Journal, gave a talk on automatic transmissions to the Western Electric Science & Engineering Club in Newark, on Sept. 27.

LESTER J. HOWARD, who, prior to this, was garage foreman with Pioneer Mill Co., Ltd., Lahaina, Maui, T. H., is now co-owner and operator of the Willamette Boat & Engine Works, Willamette, Oreg. The company is engaged in the repairing of boats and the rebuilding of marine and truck engines.

J. EDWARD SCHIPPER, vice-president of Kudner Agency, Inc., New York, and formerly president of Schipper associates resigned from Kudner Agency on October 15. Schipper is again opening his own office in Detroit as public relations counsel and will include the Kudner Agency among his clients. A past chairman of SAE Detroit Section (1918-19), Schipper operated his own public relations business in Detroit for 15 years prior to joining the Kudner Agency. He is a member of the Contest Board of the American Automobile Association and has long been active in engineering, public relations and advertising in the automotive field. Schipper will maintain his new offices in the New Center Building, Detroit.

LLOYD B. POOLE has been appointed general sales manager of the Bokar Corp., Dexter, Mich. Well known in the automotive after-market,

he has a background of twenty years in the industry. Formerly, he was manufacturers' agent for a number of automotive after-market lines, and previously associated with Butler Engineering Co., Firestone Tire and Rubber Co. and National Carbon Co.

OBITUARIES

GEORGE S. CASE, SR.

George S. Case, Sr., an SAE member for forty years, passed away on October 11. He was chairman of the board at Lamson & Sessions Co., Cleveland, Ohio.

Case was born in Interlaken, N. Y., and was educated at the University School in Cleveland. He received his degree of B.S. from Case School of Applied Science in 1904. Shortly after graduation he joined Lamson & Sessions, and worked in various capacities, until he became president of the company in 1929. Nine years later he became chairman of the board.

He was an active and influential member of the SAE Screw Threads Committee. Prior to that, he was in the Screw Threads Division of the General Standards Committee. In October, 1922 he was appointed as one of the two SAE members on the NSTC. He was one of the SAE representatives on Sectional Committee B 1, and was very active in connection with the American British Canadian Unification Screw Threads Program. He went to Europe as official delegate in connection with the ABC Program in 1910.

BRIG.-GEN. C. L. FIKE

Brig.-Gen. Charles L. Fike died May 3 at Bryn Mawr Hospital of injury sustained in an automobile accident.

General Fike was a graduate of the U. S. Naval Academy (1924) and of the University of Michigan. During World War II he led the first Navy and Marine air units based on Guadalcanal. He served in the Marine Corps for 20 years, during which he received the Distinguished Service Medal, the Distinguished Flying Cross and Bronze Star. He joined The Budd Co. in July, 1946, and for the past three years had been executive engineer under Major-Gen. G. M. Barnes, vice-president in charge of engineering.

He had been an SAE member since 1932.

Students Enter Industry

JACK E. FLEMING (Bradley University '50) to Hyster Co., Peoria, Ill.

RALPH E. FORD (Wayne University '50) to Woodall Industries Inc., Detroit.

DAVID E. FYFFE (Purdue University '50) to Sinclair Refining Co., (Research and Development), Harvey, Ill.

RAYMOND A. GALLANT (Rensselaer Polytechnic Institute '50) to Research Laboratories Division, GMC, Detroit.

PHILLIP BARTON GARNER (California State Polytechnic College '50) to AiResearch Mfg. Co., Los Angeles.

WILLIAM JOHN GERSTENMAIER (Yale University '50) to Barden Corp., Danbury, Conn.

HARRY LEROY GREENE (University of Southern California '50) to United States Bureau of Reclamation, Coulee Dam, Wash.

RICHARD CHARLES BOWLES (University of Southern California '50) to Kaiser Steel Corp., Fontana, Calif.

RAY E. ASHLEY, JR. (University of Oklahoma '50) to Griffin Grocery Co., Muskogee, Okla.

NORMAN LOUIS BONEMA (Michigan College of Mining and Technology '50) to Keller Tool Co., Grand Haven, Mich.

JAMES J. BRADY (Northrop Aeronautical Institute '50) to H. L. Yoh Consulting Engineers, Philadelphia.

JACKSON G. BYERS (University of Michigan '50) to Pontiac Motor Division (GMC), Pontiac, Mich.

LILLORD COBB (Lawrence Institute of Technology '50) to Ford Motor Co., Dearborn, Mich.

ANTHONY N. COTA (Bradley University '50) to Automatic Electric Co., Chicago.

THOMAS A. COX (University of Wisconsin '50) to J. I. Case Co., Burlington, Iowa.

IGNAZIO J. D'AGATI (New York University, College of Engineering '50) to Robins Engineers, New York City.

CHARLES MARSHALL DAVIDSON (Yale University '50) to Armstrong Rubber Co., West Haven, Conn.

ARNOLD R. BLOOMQUIST (University of Minnesota '50) to Aluminum Co. of America, Cleveland.

CHARLES J. JACOBUS (Northwestern University, Technical Institute '50) to White Motor Co., Chicago.

ROBERT T. KOHLER (Bradley University '50) to Drying Systems, Inc., Chicago.

JOSEPH G. MILLER (University of Wisconsin '50) to Miller Bros. Iron and Metal Co., Milwaukee.

REGINALD W. PAULEY (Rutgers University '50) to Wright Aeronautical Corp., Wood-Ridge, New Jersey.

JOHN H. SALOMON (Yale University '50) to United Illuminating Co., New Haven, Conn.

WILLIAM JAMES SEITZ (University of Cincinnati '50) to Jennings Buick, Inc., Cincinnati.

ROBERT DAVIS (Indiana Technical College '50) to Edo Corp., College Point, New York.

JOSEPH T. FLEMING (Yale University '50) to Hamilton Standard Propellers Division, United Aircraft Corp., East Hartford, Conn.

CHRISTO ANDREA (University of Massachusetts '50) to Pratt & Whitney Aircraft, Division of United Aircraft Corp., East Hartford, Conn.

RUSSEL H. NUTTER, (Cornell University '50) to Detroit Gear Division, Borg-Warner Corp., Detroit.

JOSEPH J. PAVELKA (General Motors Institute '50) to Buick-Oldsmobile-Pontiac-Assembly Division, GMC, Linden, N. J.

JOHN FREDERICK HENDEL (Tri-State College '50) to McDonnell Aircraft Corp., St. Louis, Missouri.

JOHN D. KOETTER (Bradley University '50) to Allis-Chalmers Mfg. Co., Tractor Division, Milwaukee.

CARL G. SANTESSON (Oregon State College '50) to Mobilift Corp., Portland, Ore.

ALBERT WITHEROW BITZER (Carnegie Institute of Technology '50) to Heintz Mfg. Co., Philadelphia.

EARL ARTHUR THORWALL (Lawrence Institute of Technology '50) to Glenvale Products Corp., Detroit.

RALPH SHEPHERD PARKS (Michigan State College '50) to Reo Motors, Inc., Lansing, Mich.

WILLIAM H. MEIXNER, JR. (Lawrence Institute of Technology '50) to Chrysler Corp., Dearborn, Mich.

KAINO BOB MASAMITSU (University of Illinois '50) to M. W. Welch Mfg. Co., Chicago.

HARRY ASHER (Illinois Institute of Technology '50) to Elgin National Watch Co., Elgin, Ill.

JOHN H. SPAAN III (Oklahoma A & M College '50) to John Henry's Service Station, Oklahoma City.

LAWRENCE A. VENERE (Aeronautical University '50) to Delta Star Electric Co., Chicago.

JEROME JACOBSON (University of Illinois '50) to General Electric Co., Schenectady, N. Y.

ROBERT LEWIS JONES (Purdue University '50) to Pratt & Whitney Aircraft, Division of United Aircraft Corp., East Hartford, Conn.

DONALD PHILLIP ALLEN (University of California '50) to Ford Motor Co., Richmond, Calif.

MARK DICK (Oregon State College '50) to Universal Oil Products Co., Riverside, Ill.

HARVEY J. CHRISTENSEN (Purdue University '50) to Caterpillar Tractor Co., Peoria, Ill.

ALFRED CHARLES LITTLE (University of Buffalo '50) to Fedders-Quigan Corp., Buffalo, N. Y.

CHARLES EITZEN (Academy of Aeronautics '50) to Aircraft Maintenance International, Idlewild, N. Y.

STANLEY VINCENT PTASZNIK (Northrop Aeronautical Institute '50) to Hartford-Empire Co., Hartford, Conn.

GILES EMERY SMITH (University of Washington '50) to Kenworth Motor Truck Corp., Seattle.

DAVID BEDERMAN (Aeronautical University '50) to Consolidated-Vultee Aircraft Corp., San Diego, Calif.

EDWIN E. HEBB, JR., (Chrysler Institute of Engineering '50) to Detroit Diesel Engine Division, GMC, Detroit.

WILLIAM C. CLAS (Indiana Technical College '50) to Albany Designing, Inc., Albany, N. Y.

ALBERT W. BERG (University of Illinois '50) to Wright-Patterson Air Force Base, Dayton, Ohio.

WARREN A. OLSON (Cal-Aero Technical Institute '50) to North American Aviation, Inc., Los Angeles, Calif.

Continued on Page 104

TECHNICAL COMMITTEE

Progress

Revised SAE Oil Grades Score Three-Way Advance

THE newly revised SAE Crankcase Oil Classification eliminates two motor oil grades, is more logical, and sets up oils for a wider operating range than its predecessor. Vehicle manufacturer, oil refiner, and the motorist stand to gain from these changes.

The new classification is shown in Table 1, the one it replaces, in Table 2. In comparing the two, note first that grades 60 and 70 have been eliminated. (This was approved earlier this year.) They were dropped because of their extremely limited usage.

Second significant change is the addition of the 5W classification. The 5W oils are considered desirable for subzero operation, particularly cold

starting. Studies made by a group of the SAE Fuels & Lubricants Committee, in cooperation with CRC, showed that using 5W instead of 10W oil brings a 33% average increase in cranking speed. These researches also disclosed satisfactory viscosity stability, oil consumption, and wear resistance with 5W oils.

Car manufacturers have recommended 10W oil for temperatures down to -10 F. Below this, 10W plus 10% kerosene was the usual practice. But this diluted oil was considered unsatisfactory because of its viscosity instability. The 5W oils can operate at temperatures considerably below -10 F without the disadvantage of the diluted 10W.

The winter grade oils, 10W and 20W, now a part of the SAE Crankcase Oil Classification, previously were not included. They were listed separately in

Table 1—Revised SAE Crankcase Oil Classification

SAE Viscosity Number	Viscosity Range, Saybolt Univ., Sec.			
	at 0 F		at 210 F	
	Min.	Max.	Min.	Max.
5W	—	4000	—	—
10W	6000 (Note A)	less than 12,000	—	—
20W	12,000 (Note B)	48,000	—	—
20	—	—	45	less than 58
30	—	—	58	" " 70
40	—	—	70	" " 85
50	—	—	85	110

Note A. Minimum viscosity at 0 F can be waived provided viscosity at 210 F is not below 40 Saybolt Seconds Universal.

Note B. Minimum viscosity at 0 F can be waived provided viscosity at 210 F is not below 45 Saybolt Seconds Universal.

Table 2—Former SAE Crankcase Oil Classification

SAE Viscosity Number	Viscosity Range, Saybolt Univ., Sec.			
	at 130 F		at 210 F	
	Min.	Max.	Min.	Max.
10	90	less than 120	—	—
20	120	" " 185	—	—
30	185	" " 255	—	—
40	255	—	—	less than 80
50	—	—	80	" " 105
60	—	—	105	" " 125
70	—	—	125	" " 150

SAE

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the SAE Handbook under the title Automotive Manufacturers' Viscosity Classification.

The revised Classification also is more logical because the viscosities are specified at temperatures more nearly those at which the oils operate. Winter grade viscosities are given at 0 F; the other oil viscosities are given at 210 F. The former classification specified viscosity for the 10, 20, and 30 oils at 130 F.

Advantages accrue to vehicle builder, oil refiner, and vehicle owner alike from this refinement of the old oil classification.

The manufacturer now can specify more exactly the correct lubricant for the vehicle because oil classification is more logical. The elimination of grades simplifies stocking and distribution problems of the oil refiner. And the vehicle owner gains better protection for his engine at subzero temperatures, because of the 5W oils, and he also has a better guide for changing oil.

The SAE Crankcase Oil Classification, approved Oct. 3, was revised by the SAE Fuels & Lubricants Technical Committee. Its chairman is M. D. Gjerde, Standard Oil Co. (Ind.)

Handbook Correction

THE steel numbers listed at the heads of the columns on p. 332 of the 1950 SAE Handbook are incorrect. The numbers at the column headings for Table 3d on p. 332 should be, from left to right: 4137 H, 4140 H, 4142 H, 4145 H, 4147 H, 4150 H, and 4317 H.

Bridwell Succeeded by Norelius As Construction Machinery Head

MEMBERS of the SAE Construction and Industrial Machinery Technical Committee have accepted with regret the resignation of J. W. "Jim" Bridwell, for three years chairman of the Committee. Additional responsibilities at Caterpillar Tractor Co., of which Bridwell is assistant chief engineer, made it necessary for him to drop committee work. Great credit for CIMTC's accomplishments in the earth moving equipment field is given to the outgoing chairman. His untiring energy and sympathetic understanding have been the continuity factors that have helped hold the CIMTC personnel together in a bond of fraternity with

the welfare of the customer always the determining influence in arriving at engineering standards.

Active in Society

Succeeding Bridwell as chairman of CIMTC is E. F. Norelius, consulting engineer of Springfield Works of Allis-Chalmers Mfg. Co. The new chairman, a member of SAE for 30 years, has served on many SAE committees and was one of the group who helped form CIMTC in 1946. He has been a member of the Steering Committee and chairman of the first subcommittee of CIMTC on Drawbars and Tractor Mountings since its inception. Mem-



Norelius



Bridwell

bers of the committee feel that CIMTC will maintain its outstanding record under the new leadership.

Peening Group Argues Shot Quality Testing

THE gap in correlating laboratory and production tests of shot peening and cleaning materials was narrowed at a recent two-day meeting of the Shot Peening Division, of the SAE Iron & Steel Technical Committee. Papers and discussions on original researches threw new light on shot quality testing and other phases of the Division's program. The Division members were guests of The Pangborn Corp. in Hagerstown, Md. Part of the meeting was devoted to a trip through the Pangborn plants.

A clear distinction between laboratory and production tests was called for by Don Cargill, Precision Shot Co. He described the laboratory test as one conducted by the producer before the shot goes into production, to determine if it meets minimum or predetermined quality. Production shot tests, really production methods tests, aim to evaluate the efficiency of the methods used in conjunction with the operating idiosyncracies of a given production machine.

Chief objective of one of the Division's subcommittees is to evolve a laboratory shot test that compares materials as to relative performance in production machines. All at the meeting agreed there is no such method yet.

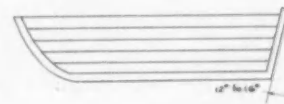
J. C. Straub, American Wheelabrator and Equipment Corp., showed one possible factor leading to this lack of correlation. He demonstrated with SN diagrams (stress versus number of cycles to failure), plotted on log-log paper, that curves for shots being compared must be parallel; otherwise the ratio of life for the two types will dif-

Technishorts

BODY NOMENCLATURE: A body and sheet metal nomenclature, with illustrations to supplement definitions, now is being developed by a subcommittee of the SAE Body Engineering Committee. Among the parts considered for the terminology, to be published in the SAE Handbook, are braces, brackets, covers, and doors. H. V. Woodward, Chevrolet Motor Division, GMC, recently succeeded W. Robertson as chairman of the Subcommittee.

CHAIN STANDARDS: Adoption of a new proposed American Standard on chains and revision of another recently was recommended by SAE and ASME, co-sponsors of ASA Sectional Committee B29, Transmission Chains and Sprocket Teeth. The new proposed Standard covers inverted tooth (silent) chains and sprockets; the revised one, transmission roller chains and sprockets. Both Standards are being submitted to American Standards Association for final approval and adoption as an American Standard. SAE is administrative sponsor of this project.

MOTORBOAT TRANSOMS: Transom location and dimensions on boats for mounting outboard motors, in an SAE Recommended Practice, have been revised. (See sketch at right.) The transom slope angle, formerly specified as 12 deg minimum, has been changed to "12 deg minimum to 16 deg maximum." Aim of the revision is to help control this angle in boat production. If the angle is above or below these specified limits, and some boats have been made that way, the outboard motor will not operate efficiently.



HEAT TRANSFER: An extensive treatise on heat transfer is being developed by the SAE Aircraft Air Conditioning Equipment Committee. This report, one of a growing series in aircraft heating and air conditioning being prepared by the group, will include fundamental heat transfer data and properties of materials useful in this field.

LIGHTING SPECS: Revisions have been approved in the following SAE Recommended Practices for Motor Vehicle Lighting Devices: clearance, side-marker, identification, and parking lamps; stop lamps; tail lamps; school bus warning lamps; turn signal units and turn signal operating units; lighting equipment for motor vehicles; and data on 12-v sealed beam units. These revisions will be incorporated in the 1951 SAE Handbook. Copies of the revised Recommended Practices are available from SAE.

Turn to Page 88

fer for different wheel speed. If the curves are not parallel, the life ratio between the two varies with the applied stress.

No real agreement has been reached on the approach to either laboratory or production tests of shot materials. The Shot Quality Testing Subcommittee conducted field tests at seven different plants to compare the Straub and Ervin methods, two of several laboratory procedures said to have possibilities. The Straub test is run on the basis of average life at point of 55% failure. The Ervin test measures breakdown rate determined by continued replacement of undersized shot.

Comparison of the two methods at the seven plants,—using cut wire, cast steel, malleable iron, and hard iron shot—showed them to yield very similar results, reported N. S. Mosher, Alloy Metal Abrasive Co. However, it was pointed out that the average life method test takes about 40% as long as the rate-of-breakdown method.

Shot users argued that lab test machines are of little use to them. They felt consumer acceptance tests should not take hours or days to run. This is particularly so with the advent of premium shot.

Cargill described a production methods test that gives a day-to-day picture of equipment performance and provides statistical control of the operation. This three-step method consists of:

1. Record each shot addition by recording weight of each addition and operating hours since last addition. If shot is added every day, record daily shot additions and daily hours of operation. This is simplified by connecting an elapsed-time recording clock to the shot slinging motor. Clock readings taken when shot is added will show hours of operation between additions.

2. On a computation sheet, accumulate shot additions and the elapsed times, so that the last figure in each column shows both the total shot added and the total hours of operation since the test began.

3. Plotting these accumulated shot totals versus the respective accumulated hours of operations gives a rate curve. Dips and jumps in the curve indicate effects of machine conditions, personnel, and so forth. "Straightness" of this rate curve indicates accuracy of the test. Variations that cause the curve to veer show up as soon as they occur. Also shown in the extent to which they alter the shot consumption rate. Because the chart shows when these things happen, they can be dealt with quickly.

Cargill also showed the application of these data in comparing cleaning costs of various shot. While four shot types were run, tabulations were kept of amount of material cleaned, amount

You'll Be Interested to Know

GENERAL CHAIRMEN HAVE BEEN NAMED for four SAE National Meetings in 1951. R. H. Kelley, Chevrolet's chief engineer, is general chairman for the Passenger Car, Body, and Materials Meeting in Detroit; F. B. Lautzenhiser, International Harvester consulting engineer, for the Transportation Meeting in Chicago; Merrill R. Bennett, assistant chief engineer of International Harvester, for the National Diesel Engine Meeting in Chicago; and Maurice L. Hamilton, assistant director of Sinclair's engine laboratory, for the National Fuels and Lubricants Meeting in Chicago.

NEW MONTREAL SECTION HAS been authorized to add to its elective officers a regional vice-chairman to represent Ottawa—and an Aircraft Activity vice-chairman and a Transportation & Maintenance Activity vice-chairman.

ANOTHER NEW SECTION HAS BEEN ADDED. Former Mid-Michigan Division of the Detroit Section is now SAE Mid-Michigan Section. Its territory embraces the following Michigan counties: Bay, Clinton, Genesee, Gratiot, Ingham, Lapeer, Midland, Saginaw, Shiawassee, and Tuscola. SAE Council authorized the new Section, with the endorsement of the Detroit Section, at its Sept. 14 meeting. . . . This brings the total of SAE Sections to 36. (SAE Groups number 5).



HENRY FORD MEMORIAL AWARD has been established by the SAE Detroit Section "for the encouragement of the young engineer in the field of automotive ground vehicles." The Award will be made annually to the SAE member under 33 years of age (regardless of membership grade) who is author of the best original paper on an automotive ground vehicle subject. Selection of the Award-winning paper will be made by a committee of three judges, appointed by the Chairman of the Detroit Section.

Any SAE member under 33 years of age is eligible to compete for this Award. The contest is **not** limited to Detroit Section members. Other rules governing the Award include:

The paper shall describe an engineering work, or record an engineering investigation, with which the author has been directly associated; The paper must be presented or be suitable for presentation to an SAE meeting;

All eligible papers submitted during the Detroit Section fiscal year of June 1 to May 30 will be considered.

The Award consists of an appropriate certificate of merit, plus a substantial cash prize. It was established as a tribute by the Detroit Section to the late Henry Ford because: "He had a deep and abiding interest in the young engineer. Mr. Ford's efforts to encourage and assist such young men were unremitting over his long, active life."

W. G. LUNDQUIST, C. E. FRUDDEN, AND E. S. MACPHERSON have been named SAE directors on the Board of the Coordinating Research Council for the two-year term beginning Jan. 1, 1951. Frudden and MacPherson will be serving their second two-year term. SAE-CRC Directors who still have one year of their two-year terms to serve are: E. N. Cole, G. J. Huebner, Jr., R. D. Kelly, and Arthur Nutt.

LOYOLA UNIVERSITY at Los Angeles, Calif. has the newest SAE Student Branch Charter. SAE Council at its Sept. 14 meeting approved the Branch Charter for the 3-year-old Loyola SAE Student Club. The Club's petition had specific endorsement from the president and the dean of engineering of the university, whose school of engineering offers B.S. degrees in civil, mechanical, and electrical engineering.

Continued on Page 100

SAE Section Meetings

Racing Engine Developments Highlighted

• Metropolitan Section
C. F. Foell, Field Editor

Sept. 13—In his talk about the Cummins Diesel race car, before the members of the Metropolitan Section, J. C. Miller, Jr., manager of research and

development, Cummins Engine Co., gave highlights of the racing engine development. As a commercial model, the basic unit is the JBS 600 engine, rated 150 hp at 2500 rpm and intended principally for trucks of medium weight.

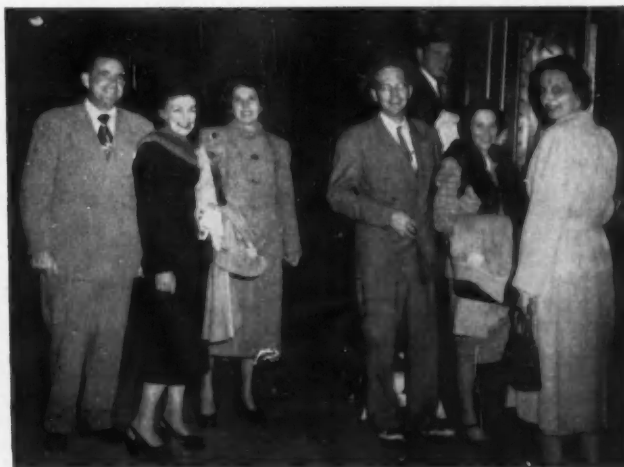
Cut-and-try methods on a laboratory test unit eventually produced an engine of approximately $14\frac{1}{2}$ to 1 compression ratio, fitted with a 4-valve-per-cyl head, turning at 3600 rpm nominal

rated speed, and supercharged from an attached blower. At the rated speed, some 300 hp was developed, the maximum available being about 340 hp at 4000 rpm.

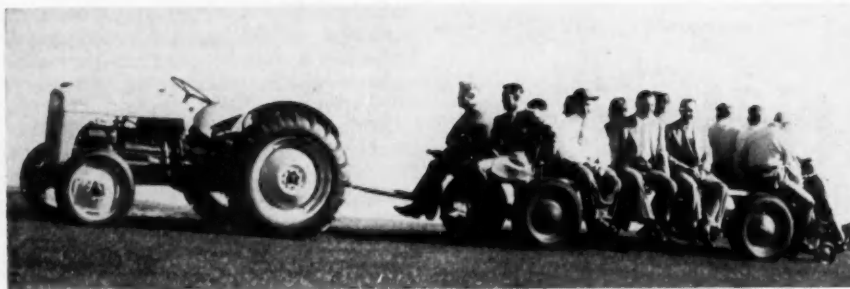
Widespread use of aluminum can reduce engine weight to meet the need for over-all restrictions on vehicle weight. Because of the use of aluminum, the completed racing engine weighed 600 lb less than the commercial prototype. The engine was fitted to a Kurtis-Kraft chassis shortly before the scheduled start of the qualifying runs at the 500-mile Indianapolis Race, during which the Cummins entry made an official qualifying run of 129.208 mph. In the race itself, the Cummins car completed 52 laps and attained speeds as high as 120 mph.

Miller also revealed that the same unit on the salt flats in Utah recently attained a speed of 165.25 mph per measured mile (an average of speeds in opposite directions), to set a new diesel record. (This paper was presented also at the SAE National West

DETROIT SECTION AT WHITE SULPHUR



Sept. 15 and 16—Over 200 Detroit Section members assembled by car and special train at the Greenbrier Hotel in White Sulphur Springs for a weekend of golf, bridge, canasta and general social enjoyment. Included were two off-the-record technical sessions headed by W. H. Graves, Packard Motor Car Co., and M. A. Thorne, General Motors Corp.



SAE members at the Milwaukee Section outing on the day following the National Tractor Meeting getting first-hand knowledge of a new "remote control" tractor, brought and demonstrated by its inventor, Baldwin Kuntz, a Ford tractor dealer from Juneau, Wis. The tractor is operated by the hand-held automatic release shown in the picture. Kuntz got the idea for this invention while watching Juneau farmers go into the grain fields with a rack and tractor to pick up shocks of grain and take them to the thresher. The tractor operator had to drive to a shock, get off the tractor, pitch the shock onto the rack, and get back on the tractor again. His remote control unit allows the farmer to drive the tractor while walking beside it

Coast Meeting. Excerpts appear in the October SAE Journal.)

This meeting marked the resumption of the Metropolitan Section's dinner meeting programs, after approximately eight years.

Importance of "Shirt-Sleeve" Designing Stressed

• Milwaukee Section
E. L. Conn, Field Editor

Oct. 6—The "Shirt Sleeve Designing" function—what is done after an engine has been designed and put into service in the laboratory and field—uncovers the unknown factors in engine design, said Paul W. Eells, vice-president in charge of engineering and manufacturing, Le Roi Co.

Eells discussed design and development of a Le Roi, V-12 industrial engine to illustrate the importance of this phase of engine development. However, he stressed that the importance of analytic or graphic investigations should not be belittled. In fact, he said, this preliminary work usually constitutes a major portion of the job of design and development. It is the responsibility of the designer to do the best he knows how, and then the lab-

oratory and field does the rest of the job.

The particular engine used to illustrate the principles of "Shirt Sleeve Designing" was conceived as a result of the usual market survey to find in general what was wanted. After the basic specifications of power, speed, weight, and so forth, had been determined, the next step was to consider whether the engine should be a "straight" or "vee" type. Comparative data tabulation of a V-12, a straight 6, a straight-8, and a V-16, resulted in a decision to build a 7 1/4 in. bore by 7 in. stroke, V-12 engine with a 75 deg angle between the cylinders.

Using slides, Eells showed the power characteristics and design features. While doing so, he made comments on places in the engine which in either the laboratory or field had shown the need for some "shirt sleeve designing."

Most of his talk was about the basic features, such as: crankcase, camshaft and auxiliary drives, cylinder and cylinder head, valve mechanism, crankshaft, and lubricating oil system. Eells ended his talk without drawing any conclusions, because, as he remarked, there is no engine design which can ever be considered as being final.

Discussion which followed, centered mostly about some of the more unique features of the V-12 engine which had been used to illustrate the subject. Eells, assisted by members of his en-

gineering staff, answered that the wider angle between the cylinders had been adopted to make room for the camshaft within the "V", and also to avoid the inherent sixth-order critical of a 60 deg. V-12 engine. Major trouble with the hydraulic valve lifters, it was said, is caused by air in the oil supply. Correction of this results in satisfactory operation. With regard to the valve mechanism, Eells remarked that one major problem had been to obtain satisfactory dimensions of all related parts so that valve spring loading was sufficient. Another correction was required to prevent the valve from rotating after it had started to seat.

The bore was made larger than the stroke, he indicated, to provide an ample space for the valves, not out of consideration of the breathing capacity of the engine. Measurement of the volumetric efficiency had not been made, he said.

Eells stated that the major advantage of the cast iron shaft was the reduced weight, and the resulting reduction of bearing loads. He stressed that the hardness and torsional rigidity of the shaft material are important. Another interesting feature of the shaft was counterweights at the center which eliminated the necessity of having a larger main bearing at the center of the engine, thus the main bearings were all interchangeable.

Cites Advantages of New Transmission

• Buffalo Section
D. C. Appelby, Field Editor

Sept. 21—The particular combination of engine, torque converter and automatic transmission, used by Chevrolet, provide a new standard of performance, flexibility, smoothness, and ease of operation, explained Robert S. Plexico to over 100 Buffalo Section members and visitors.

A design based on desire for best all-around performance and economy has resulted in present Chevrolet automatic transmission, said Plexico, who is chief transmission engineer for the Chevrolet Motor Co.

Plexico went on to trace the design of the unit. This was followed by a discussion of operating economies, mechanical expectancies, cooling characteristics and other technical details.

A paper titled "Chevrolet's Automatic Transmission," appeared in the October issue of the SAE Journal. Written by Plexico in conjunction with R. E. Kaufman, it gave a detailed description of the above mentioned transmission and its workings.

Prior to the meeting, Section Chairman, Robert D. Best presented a certificate of appreciation to last year's Section Chairman, Ellsworth Boeck.



Some of the members of the SAE Student Club at the Pennsylvania State College, shown with one of their faculty advisers, Professor Dilworth (lower right)

Northrop's main campus at Hawthorne, Calif., showing, from front to back: the administrative building; the building housing the drafting room, library, study hall, powerplant classroom and hydraulics classroom; the shop building, with sheet metal fabrication, foundry, welding shop, machine shop, engines laboratory, structures laboratory, and 14 classrooms; and the wood shop and airplane repair shop



SAE AT NORTHROP

STUDENT enthusiasm and wholehearted faculty support have helped make the Student Branch at Northrop Aeronautical Institute the largest of the SAE Branches. The Institute itself is only eight years old. Within a year after the Student Branch charter was granted in 1947, enrollment had grown to almost 500—and most of the members were participating actively.

Early in 1948 the Branch sponsored and made all arrangements for a dinner and inspection trip through the Northrop plant. Present were almost 1000 students and SAE Section members. In the same year, other student organizations cut into membership and gave the SAE Branch a new goal: unable to be the largest branch, they decided to be the best in the country. How well they succeeded is shown by the fact that through the excellence of their meetings and the orderly conduct of their affairs they attracted more and more students and again became the biggest branch in the country.

From the start they have been

blessed with excellent officers who have promoted good student attendance at the regular Section meetings. Their alliance with Southern California Section has been close and profitable. Many have graduated to active participation in the Section. Two past officers are committee chairmen. Through their SAE affiliation, many Northrop students obtained jobs in other-than-aircraft work.

During the nearly four years of its existence, the Branch has held at least twelve meetings a year. Their speakers have included Prof. Peter Kyropoulos, student adviser of the Cal-Tech Student Branch; the late SAE Past-President Mac Short, vice-president of Lockheed Aircraft Corp.; Southern California Chairman Reagan Stunkel, president of Aviation Maintenance Corp.; and representatives of most of the other important West Coast aircraft manufacturers. They have made many field trips to airplane plants, wind tunnels, and automobile assembly plants.

As faculty adviser, M. V. Christman helped organize the Branch and has contributed materially to its success through the past three and a half years. John Ward, head of engineering drafting, took over the job when Christman left Northrop recently.

SAE MEMBERS WHO ATTENDED NORTHROP AERONAUTICAL INSTITUTE INCLUDE:

Adolph F. Avondo (1947-49), Allen G. Barclay (1946-48), Donald R. Bull (1946-48), Richard L. Catlin (1947-49), Richard J. Chwalek (1947-49), Lloyd L. Clevenger (1947-49), Roland E. Gagon (1946-48), William H. Gates (1947-49), Theodore R. Gensel (1946-48), Melvin W. Hall (1945-47).

Floyd T. Horton, Jr. (1946-48), William E. Kell (1946-48), Clarence L. Kirsch (1947-49), Walter M. Kobler (1947-49), Nickolas J. Linardos (1946-48), Donald S. Marden (1947-48), Myron E. Morrison, Jr. (1947-49), Nor-

NORTHROP STUDENTS AT WORK



Hydraulics Instructor Darling (back to camera) discusses with students the hydraulic installation on the mockup of the School Project 04. The propeller is attached in order to check clearances. Shop work, including engineering structures testing, is being conducted in the background



Large drafting room on the main campus. Standing in the second row is M. V. Christman, former SAE faculty adviser, who was also in charge of the drafting program. Standing in the third row is F. E. Bullock, design drafting instructor. All drafting work for the school airplane (Project 04) is conducted in this room

bert C. Myers (1946-48), Robert A. Norvell (1947-49), Darrell Page (1946-48).

Henry A. Pyzdrowski (1947-48), Robert M. Seeley (1946-48), James E. Stadler (1947-49), Nick G. Stasinos (1947-49), Charles H. Swan (1946-47), Robert L. Vandever (1946-48), Averil Dean Walker (1948-50), Glen F. Werner (1946-47), Paul W. Wyckoff (1947-49).

See Research Projects At First Section Meeting

• Williamsport Group
Carmine Pinto, Field Editor

Sept. 11—Williamsport Group members met at the Engineering Experiment Station of the Pennsylvania State College to make a thorough inspection tour of research projects being undertaken there. These included:

- Study of combustion phenomena in a reciprocating engine;
- Development of a closed-circuit high-altitude lubrication system;
- High-speed cam design;
- Investigations on exhaust manifolds for multi-cylinder engines by means of an air and a water model;
- Study of grease-lubricated journal bearings; and

- Influence of cutting oils on tool life.

All of these projects are carried out under the sponsorship of industrial concerns or government agencies. The equipment was shown in operation and pertinent facts about it explained.

Prof. R. L. Stanley reported on aims and activities of the Engineering Experiment Station. Prof. W. E. Meyer gave a short talk on the Texaco Combustion Process. He explained that it uses a cylindrical combustion chamber in which an injection nozzle and spark plug are arranged so that with air rotation in the chamber, a combustible mixture is produced along the radius of the chamber at the spark plug. The initial portion of the mixture is ignited by the spark. From then on, as a new mixture is prepared by the coaction of air rotation and fuel injection, a stationary flame front develops opposite the sparkplug while the products of combustion leave the zone of burning on the downstream side, until either fuel injection terminates or the gas mass in the chamber has completed one full revolution. Since there is never any "end gas" present in the chamber, detonation will not occur no matter how low the octane rating of the gasoline. Even with a low compression ratio, the engine will operate with kerosene or diesel fuel without knocking because the ignition delay is con-

25 Years Ago

Facts and Opinions from SAE Journal of November, 1925

An SAE Northern California Section with headquarters in San Francisco was inaugurated on Sept. 28. E. C. Wood was chosen chairman; Grahame B. Ridley, vice-chairman; Charles W. Gebhardt, treasurer, and W. S. Crowell, secretary.

A recent investigation of the extent to which sheet steel is tested by users shows that tests are seldom made. W. C. Peterson, chairman, told the Subdivision on Sheet Steel. Reliance is placed entirely on the use of proper forming dies and machines for working the sheet steel, he said.

Survey shows that 11 different threads for control-lever ball-handle inserts are used by car manufacturers. Only 5 of the 36 companies checked are using the thread published by SAE as "standard." As a result, the Transmission Division is to review current practice and draw up a revised standard.

Orville Wright was among the guests at the speakers' table at the Aeronautic Meeting dinner.

For a ground speed of 70 mph—or about 25 mph less than the present planes' cruising speed in still air—the on-time performance of the Air Mail varies from 73% during the winter to 98% during the summer, or an annual average of 85.8%—J. Parker VanZandt in "Reliability as a Factor in Air Transportation Efficiency."

"There is important news in aviation," C. M. Keys of Curtiss told an Aeronautic Dinner audience. "I believe that the definite entry of Henry Ford into commercial aviation, even though he came in on an experimental basis, is the most significant news of the year. It is

big news principally because, in coming in, the Ford interests really were answering what seemed to be a definite call from the public of the United States for aviation on a respectable scale."

Report from SAE Council meeting estimates that the income of the Society for the year will be about \$330,000.

In addition to increased dependability and reduced weight, according to George Mead, Pratt & Whitney Aircraft Co., the radial type of air-cooled engine makes possible an aerodynamically superior and symmetrical fuselage and gives a high center of thrust that allows ample propeller diameter.

The automotive industry has depended on the holding power of wood screws for many important structural parts. It will be interested, therefore, in knowing that the Bureau of Standards has recently conducted tests of over 10,000 wood screws of various sizes, using yellow poplar, cypress, sycamore, Georgia pine, North Carolina pine, hard maple, and white oak.

That there might be a standard system of designating ball-bearing types which would permit absolute identification by the SAE Bearings Division has appointed a Subdivision to review the present numbering system and to recommend proper changes.

The Bureau of Mines has just issued its 12th semi-annual motor-gasoline survey. . . . Much discussion has been had of the general change in quality of gasoline since 1915. The fluctuations that have taken place from year to year have followed no regular course; gasoline has not grown steadily more volatile, or less volatile.

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trolled by the spark timing.

The closed-circuit high-altitude lubrication system, explained by Prof. J. J. DeCarolus, uses an eductor to utilize energy from the scavenge pump to pressurize the pressure pump. With a pressure pump inlet pressure of about 5 psi above atmospheric pressure, the closed-circuit system has performed satisfactorily in the laboratory up to 60,000 ft altitude. It is believed that this system can be made to function properly even at a much higher altitude.

Transmission Design Ground Rules Cited

• Cincinnati Section

Walter Walkenhorst Jr., Field Editor

Sept. 26—The following sixteen principles of design and operating characteristics of the automatic transmission were aimed for and achieved by Studebaker, according to M. P. deBlumenthal, assistant chief research engineer, Studebaker Corp., South Bend, Indiana. DeBlumenthal presented these ground rules, that Studebaker felt were necessary in an automatic transmission design, to 150 members and visitors at the first fall meeting of the Cincinnati Section.

Principles of Design

They are (1) performance and driving flexibility, equal to or better than over-drive; (2) adaptability to standard powerplant; (3) elimination of the clutch pedal; (4) automatic selection of the required gear in the driving range, regardless of the throttle position; (5) down-hill engine braking, equal to or better than second gear, in a sliding gear transmission; (6) manual overrule or kickdown from direct to intermediate gear; (7) hydrokinetic means for boosting torque for starting or acceleration in geared ratios; (8) positive mechanical drive in direct to eliminate slippage and preserve fuel economy; (9) no creep with car stationary and in gear, and retention of hill-holder characteristics; (10) lockout of reverse while car is in forward motion, yet retaining ability to rock, as in snow or mud; (11) transmission cooling system independent of engine cooling system; (12) taxi push at relatively low speeds; (13) engine cranking by starter in neutral or park positions only; (14) readily accessible and easily replaceable sub-assemblies, for simplicity of service; (15) mechanical parking lock; (16) no timed or overlap shifting in automatic selection of gears.

Jet Engine Racer Not Practical, Shaw Says

• Central Illinois Section

Harlow Piper, Field Editor

Sept. 25—"Racing is a barrel of fun, but it also is a serious business," said Wilbur Shaw, president of the Indianapolis Motor Speedway Corp., and three-time winner of the Indianapolis 500 mile Memorial Day race.

In his talk "A Busy Day in Indianapolis," Shaw went on to say that the 500 mile race is part of the development branch of the automotive industry. Not only must new ideas increase speed, they also must be able to take the punishment of the world's toughest driving conditions for 500 miles.

Asked if a jet engine racer would be allowed to race, Shaw said he doubted such an engine would be practical. Besides carrying an enormous amount of fuel, the racer would have to develop about 2000 hp to get the same acceleration coming out of the turns. At present a formula is being worked out to make gas turbine cars competitive.

The displacement limit for non-

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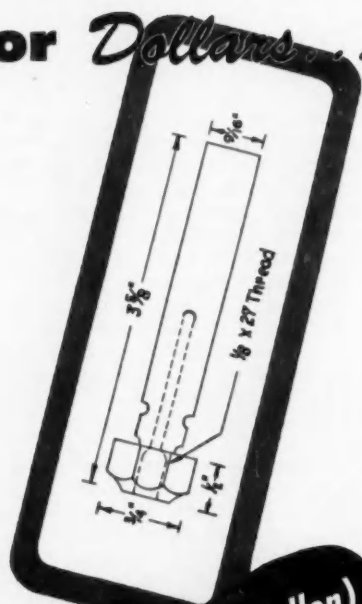
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supercharged gasoline engines is 274 cu. in. in the Memorial Day Race. The only other restriction is that the gears used in qualifying the car must be used in the race.

Most of the engines used now are modifications of the famous Offenhauser engine, Shaw said. It is a four-cylinder, four-cycle engine with 4 5/16 in. bore and 4 5/8 in. stroke. A few two-cycle engines have been tried, but the starting problems have been too great, due to the high compression.

Along with his talk, Shaw showed a technicolor movie about the design and construction of a racing car, which included exciting shots of past races.

Texaco System Eliminates Detonation With Fuel

• Williamsport Group
Carmine Pinto, Field Editor

Oct. 2—Profitable avenues of approach to low fuel consumption fall into these basic categories: (a) burning of leaner mixtures; (b) increasing of compression ratio; and (c) reduction of friction; explained Alex Taub, director,

Alex Taub Associates in presenting "Engine Design for Low Fuel Consumption."

He said the leanest possible mixture is determined by using this "miss" point as a yardstick and avoiding it with a 3% basic richer carburetor setting. With allowances for overall manufacturing variations, the final setting may be 10% richer than necessary for part throttle operation. To improve the burning of leaner mixtures: (1) the virtues of mixture stratification for ignitability; (2) mixture stratification for overall lean mixtures; and (3) higher boiling point coolants, were elaborated upon.

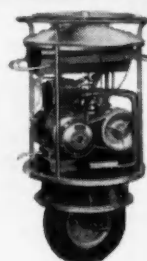
To increase compression ratio, the following were covered as possibilities where recent research has shown encouraging results: (1) approaches to mixture stratification for anti-shock and anti-detonation; (2) bore stroke ratio; (3) flywheel weight; (4) no exhaust valve; (5) cooler exhaust valve; (6) Texaco System; and (7) water injection.

Regarding the reduction of "Friction", there has been no worthwhile improvement over early engine design, and this possibility remains to be looked into by research.

Taub mentioned the Texaco System as a recent development of merit. He

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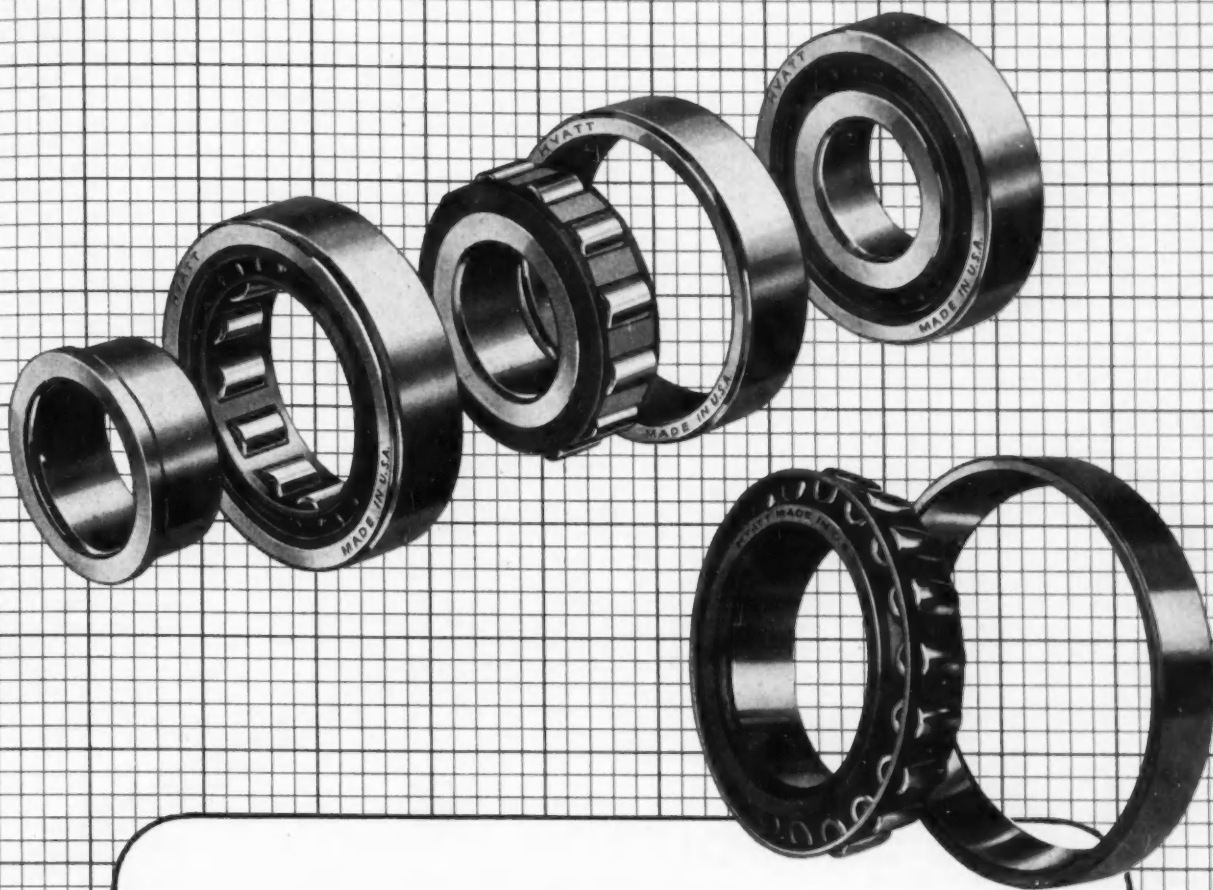
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- Permits smaller and lighter riveting equipment, hence, less worker fatigue.
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said that this system eliminates detonation with any fuel, and that it is accomplished by injecting fuel into whirling compressed air in the combustion chamber, in such a manner that there is little or no fuel to detonate.

The "No Exhaust Valve Engine", such as the Skinner sleeve valve engine, could be improved upon regarding increase in compression ratio with present day fuels, according to Taub, if industry would permit itself to de-

viate from the present poppet valve engine. Taub was blunt in saying that industry is retarding the progress of improved engine design for lower fuel consumption. This is due he claimed to the cost factor involved in the obsolescence of old tooling and the replacement with newly designed parts and tools for mass production purposes.

Robert B. Ingram, Past Chairman, Williamsport Group was awarded the SAE certificate for excellent achievement during the 1949-1950 season.

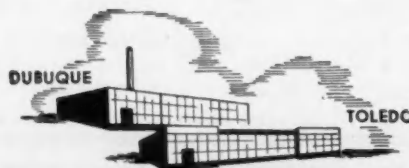
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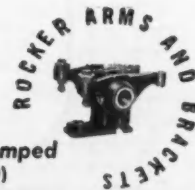
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STUDENT NEWS

Aeronautical University

Members of the Aeronautical University SAE Student Branch toured United Airlines at the Chicago Midway Airport on September 1. Ramond Martes, sales executive, guided them

through the interior of a DC-6 Mainliner, the commissary, the link trainer instruction room where pilots may come at any time to receive a "check ride" and the weather bureau.

Mertes illustrated the constant attention to payload and service when he reported that pies are no longer baked with bottom crusts because most passengers don't eat it, and that consequently 50 lb of mail payload can be added to a flight.

He explained the preparation of

flights through all types of weather. Since weather is believed to be nothing more than moving masses of air, he said, each flight is planned so that there are two available routes to a given place—one an alternate in case of bad weather.

University of Oklahoma

Oct. 6 marked the first regular meeting of the SAE Student Branch, held jointly with the Mid-Continent Section. Student members heard D. L. Pastell, director of combustion research group, E. I. du Pont de Nemours & Co., present a paper on "Precombustion Reactions" with special attention to research made with motored engines, cool flames, and end gas investigations.

Pastell said that different mixtures of fuels were used at various temperatures, pressures, and compression ratios, to investigate cool flame behavior in the region of autoignition with a motored engine. This was compared with trace knock behavior in a fired engine. He found that precombustion reactions in a motored engine were similar to reactions leading to knock in a fired engine.

This investigation, according to Pastell, furnished evidence supporting the autoignition theory of knock, and evidence that radiation from advancing flame fronts is not an important factor in conditioning the end gas for occurrence of knock. (This paper appeared in digest form in the September, 1950 Journal.)—William H. McComas, Field Editor.

Detroit Institute of Technology

SAE Student Branch members heard Andrew Rylander at the Sept. 27 meeting. Rylander, who is Technical Editor, American Society of Tool Engineers Journal, spoke to the group on Tool Engineering, its scope and importance in industry.

The meeting was one of the SAE Coffee and Doughnut Hours, originated last year at this institution.

—Bruce Barton, Field Editor

Purdue University

On Oct. 3, SAE Past-President Stanwood W. Sparrow talked on problems arising in design and production of an automobile engine, to approximately 150 SAE Student Branch members and guests.


Sparrow, vice-president and director of engineering, Studebaker Corp., covered problems in design of combustion chambers, bearings, lubricating systems, and cooling systems. He also discussed some of the problems of higher compression ratios with better fuels. Sparrow's talk was illustrated by a showing of slides.

—John F. Biebesheimer, Field Editor

FASCO

CIRCUIT BREAKERS

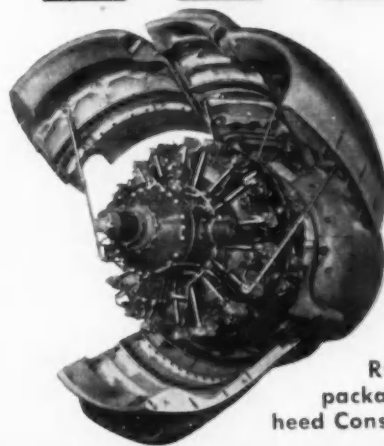
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Shot Quality Testing

Continued from Page 88

of maintenance on the machines, and shot cleaning rates. It is then simple to find the cost per ton cleaned.

Other shot peening and cleaning subjects of equal importance to the Division's efforts included a discussion

of blast cleaning operations by M. R. Wiard, Campbell, Wyant & Connon Foundry Co.; an analytical discourse on intrinsic energy values of abrasive materials by J. A. Pearson, Alloy Metal Abrasive Co.; and a cost comparison of new shot types by A. E. Proctor, Ford Motor Co.

Division Chairman R. L. Mattson, Research Laboratories Division, GMC, accepted reports on projects now under way. The proposed Shot Peening Manual, he feels, should be ready for

final approval in 1951. Among the subjects planned for inclusion in this treatise are shot peening machines, production procedures, theory of material strengthening by shot peening, and methods of shot peening leaf springs, crankshafts, axle shafts, and steering knuckles.

Approved and Proposed Aero Materials Specs

FIVE new SAE Aeronautical Materials Specifications and eight revised ones recently were approved by the SAE Technical Board. Fourteen others are being circulated to industry for comment and criticism by the SAE Aeronautical Materials Specifications Division.

a. The new ones approved are:

- AMS 5361, Steel Castings, Sand and Centrifugal, Corrosion and Heat Resistant, 18Cr—13Ni—2.5Mo
- AMS 5386, Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base—37Cr—2Ni—5Mo
- AMS 5527, Steel Sheet and Strip, Corrosion and Heat Resistant, 20Cr—9Ni—1.4Mo—1.4W—Cb—Ti, Hot Rolled and Stress Relieved, 125,000 psi
- AMS 5585, Alloy Tubing, Welded, Corrosion and Heat Resistant, Iron Base 20Cr—20Ni—20Co—3Mo—2W—1Cb + Ta
- AMS 7490, Rings, Flash Welded—Corrosion and Heat Resistant

b. The revised ones approved are:

- AMS 5385A, Alloy Castings, Precision Investment, Corrosion and Heat Resistant, Cobalt Base—27Cr—2Ni—5Mo
- AMS 5504A, Steel Sheet and Strip, Corrosion Resistant, 12.5Cr (SAE 51410)
- AMS 5521A, Steel Sheet and Strip, Corrosion and Heat Resistant 25Cr—20Ni (SAE 30310) (Deep Drawing and Spinning)
- AMS 5591A, Steel Tubing, Seamless, Corrosion Resistant, 12.5Cr (SAE 51410)
- AMS 5613B, Steel, Corrosion and Moderate Heat Resistant, 12.5Cr (SAE 51410)
- AMS 5640E, Steel, Corrosion Resistant, 18Cr—9Ni—(SAE 30303F) Free Machining
- AMS 5767A, Alloy, Corrosion and Heat Resistant, Iron Base 20Cr—20Ni—20Co—3Mo—2W—1Cb + Ta, Precipitation Treated
- AMS 5768A, Alloy, Corrosion and Heat Resistant, Iron Base 20Cr—20Ni—20Co—3Mo—2W—1Cb + Ta, Solution and Precipitation Treated

c. Those being circulated are:

- AMS 2212B, Tolerances, Magnesium

Turn to Page 102

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- AMS 6263C, Steel Carburizing, 2.25Ni—1.2Cr—0.1Mo (0.11-0.17C) (SAE 9315)

- AMS 6264C, Steel, 3.25Ni—1.2Cr—0.1Mo (0.14-0.20C) (SAE 9317)
- AMS 6266A, Steel, 1.85Ni—0.5Cr—0.25Mo—0.05V—0.004B
- AMS 6270F, Steel, 0.55Ni—0.5Cr—0.2Mo (0.11-0.17C) (SAE 8615)
- AMS 6272D, Steel Carburizing, 0.55Ni—0.5Cr—0.2Mo (0.15-0.20C) (SAE 8617)
- AMS 6274F, Steel, 0.55Ni—0.5Cr—0.2Mo (0.18-0.23C) (SAE 8620)
- AMS 6342B, Steel Bars And Forgings, 1Ni—0.8Cr—0.25Mo—(0.38-0.43C) (SAE 9840)

ings, 1Ni—0.8Cr—0.25Mo—(0.38-0.43C) (SAE 9840)

- AMS 7225B, Steel Rivets

CRC Releases Eight Reports

THE following Coordinating Research Council reports have been released for distribution and are available from SAE Special Publications Department, 29 West 39th Street, New York 18, N. Y. (This is a complete list of CRC reports released since publication of the listing of CRC reports on p. 93 of the March, 1950, SAE Journal.)

DIESEL FUELS

CRC-246—Effect of Sulfur in Diesel Fuels on Engine Operation in the Laboratory (8/1/49) Price: \$2.00 to SAE members; \$4.00 to nonmembers

AVIATION FUELS

Vapor Lock

CRC-247—Recommendations for Fuel System Design for Personal Aircraft with Regard to Vapor Lock (12/49) Price: 50¢ to SAE members; \$1.00 to nonmembers

MOTOR FUELS

Sulfur

CRC-248—Sulfur in Motor Gasoline (2/17/50) Price: \$3.00 to SAE members; \$6.00 to nonmembers

CRC-249—Report on Effect of Fuel Sulfur Content on Engine Wear and Corrosion in Laboratory Dynamometer Tests (6/7/48) Price: \$2.00 to SAE members; \$4.00 to nonmembers

DIESEL FUELS

CRC-250—Constant Volume Combustion of Diesel Fuels (1/50) Price: \$1.00 to SAE members; \$2.00 to nonmembers

CRC-251—Method for Estimating Cetane Number (4/50) Price: \$1.00 to SAE members; \$2.00 to nonmembers

MOTOR FUELS

Detonation

CRC-252—Analysis of 1948 Road Rating Exchange Data (8/4/49) Price: \$1.50 to SAE members; \$3.00 to nonmembers

CRC-253—Octane Number Requirement Survey, 1949 (2/50) Price: \$2.00 to SAE members; \$4.00 to nonmembers

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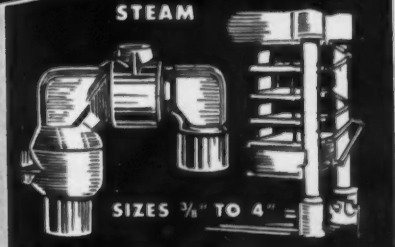
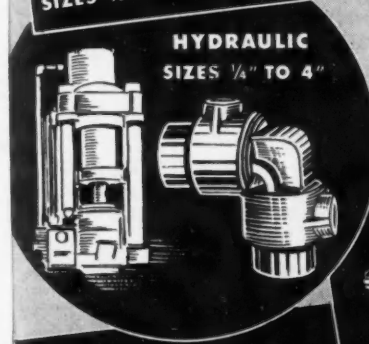
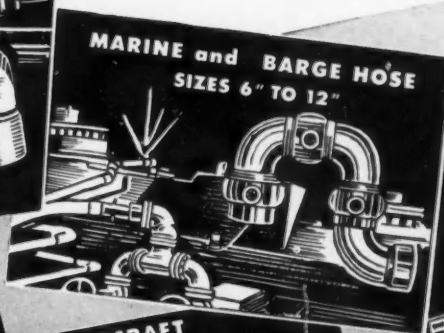
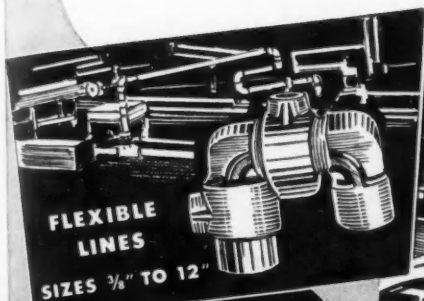
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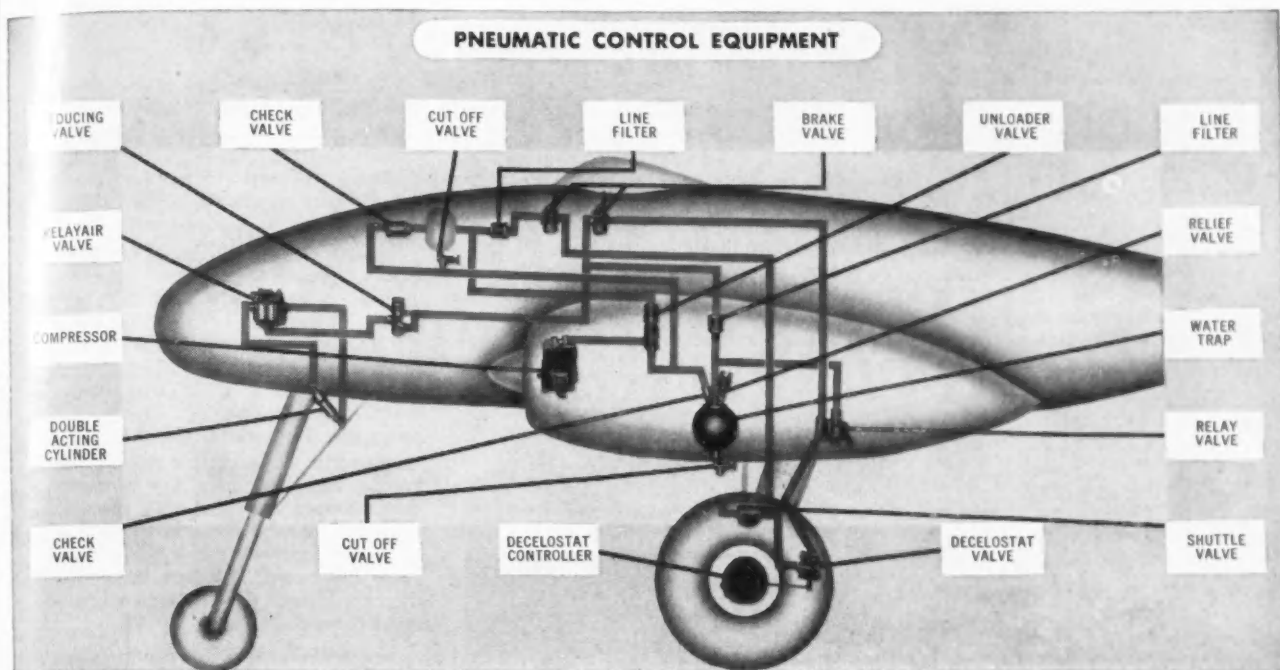
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There's an excellent reason why these pneumatic devices offer *extra* assurance of durability and reliability . . . the 82 years of company experience in air control equipment, reinforced with a research program that keeps products continuously in step with expanding needs.

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AP-1 BRAKE VALVES

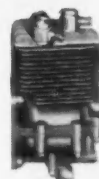
Hand operated pressure-controlling valve to maintain or control pressure to an operating unit. Pressure accurately proportioned to lever position.



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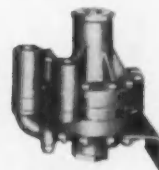


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For small two-position functions, such as camera door operation.



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Westinghouse Air Brake Company



AIRCRAFT DIVISION

Wilmerding, Pa.

Turbojet Design

Continued from Page 80

enormous combustion chambers. Since the average combustion section velocity is about one-third that leaving a typi-

cal axial stage, the combustion cross-section area must be approximately three times that of the stage discharge area. The turbine annulus area would also be very large because the air has been heated to about three times the absolute temperature leaving the compressor and its density increased, therefore, by that amount. However, the velocity here would be higher than that leaving the compressor.

As a result, the turbine annulus area would probably be in the neighborhood

of three times that of the compressor. The turbine pitch diameter, on the other hand, would have to be quite small in order to obtain an efficient velocity diagram. The resulting turbine would probably bear a degree of resemblance to a propeller.

As the pressure ratio is increased by adding stages to the rear of the compressor, the airflow and rpm remain constant, but the combustion area and turbine area decrease, due to the increase in density. The turbine pitch diameter grows. Thus, as the combustion system tends to disappear behind the compressor the turbine tends to expand beyond it. At a pressure ratio where the need for a two-stage turbine becomes apparent, the turbine makes a sudden descent back into the envelope. As the compressor pressure ratio increases, the turbine continues its growth until three stages are needed, and so on.

At certain favored pressure ratios all components lie within the compressor diameter. These will vary, of course, with the flow capacity of the compressor and the general state of the art.

Danger from Too High Airflow

Increasing the airflow per unit frontal area can be carried too far. Above some value the competent efficiencies must suffer. The question then becomes one of balancing internal drag against external drag. Due to the sensitivity of the cycle the internal drag does not have to increase much to cancel the gains in reducing external (nacelle) drag.

Turbine life is another influence. As the design airflow is increased the turbine annulus must also increase, incurring a rise in bucket stress. Thus, for the same life a lower turbine inlet temperature must be used. This reduces thrust and may harm specific fuel consumption.

A given engine design may be studied to determine the optimum design rpm. As the rpm is increased the airflow rises, but the allowable turbine temperature drops due to the rise in stress. Fig. 1 shows such a balance with all values given as net nacelle values. The powerful effects of the turbine inlet temperature and changes in component efficiency values override the benefits to external drag from increased airflow. A contributing factor is the effects on the nacelle "boat tail."

This paper also discusses other influences of high speed flight. (Paper "Influences of High Speed Flight on Turbojet Engines," was presented at SAE-IAS Meeting, New York, Mar. 16, 1950. It is available in full multi-lithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.

Turn to Page 108

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And we intend to continue to justify this faith by relentless pioneering in the field of high altitude, high speed flight.

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Market Potentials For Jet Air Transport

Based on paper by

HAL E. NOURSE

United Air Lines, Inc.

TO get maximum advantage of the higher speeds possible with the jet powered commercial plane of the

future, such planes must be capable of medium to long nonstop ranges without loss of payload. If frequent stops have to be made on flights in excess of 2000 miles, there will be little time saved by travelling in a plane with a cruising speed of 450 mph as compared with one flying at 300 mph.

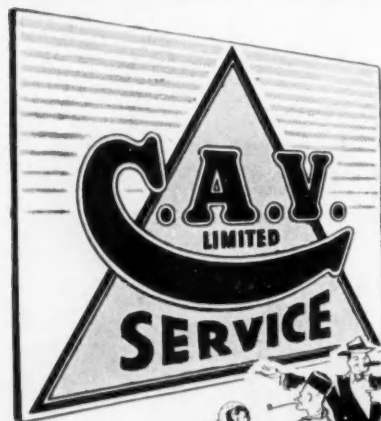
The plane of the future must be capable of lower unit cost operation than existing craft or increases in the future air market will be disappointing. However, there are indications that jet-

powered craft may open the way to operating economies as well as to lower first cost per unit of weight.

Best for Longer Flights

Due to its peculiar operating characteristics the plane of the future will probably be most effective over nonstop ranges in excess of 400 miles. For this reason and for reasons of higher passenger rates per mile, business of the future, like that of the past, will come from competition with Pullman rather than with coach or bus travel. And as in the past, again, the business will be self-generating.

The jet airplane market promises to develop slowly. Full operation over the nation is unlikely until from three to six years after the first jet schedule goes into operation. (Paper "Passenger Markets for Future Airplanes," was presented at SAE National Spring Aeronautic Meeting, New York, April 17-20, 1950. It is available in multi-lithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)



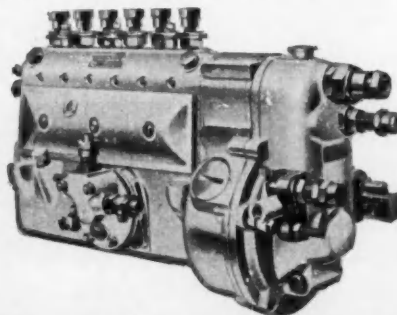
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Coming Developments In Turbojet Engines

Based on paper by

R. L. WELLS

Westinghouse Electric Corp.

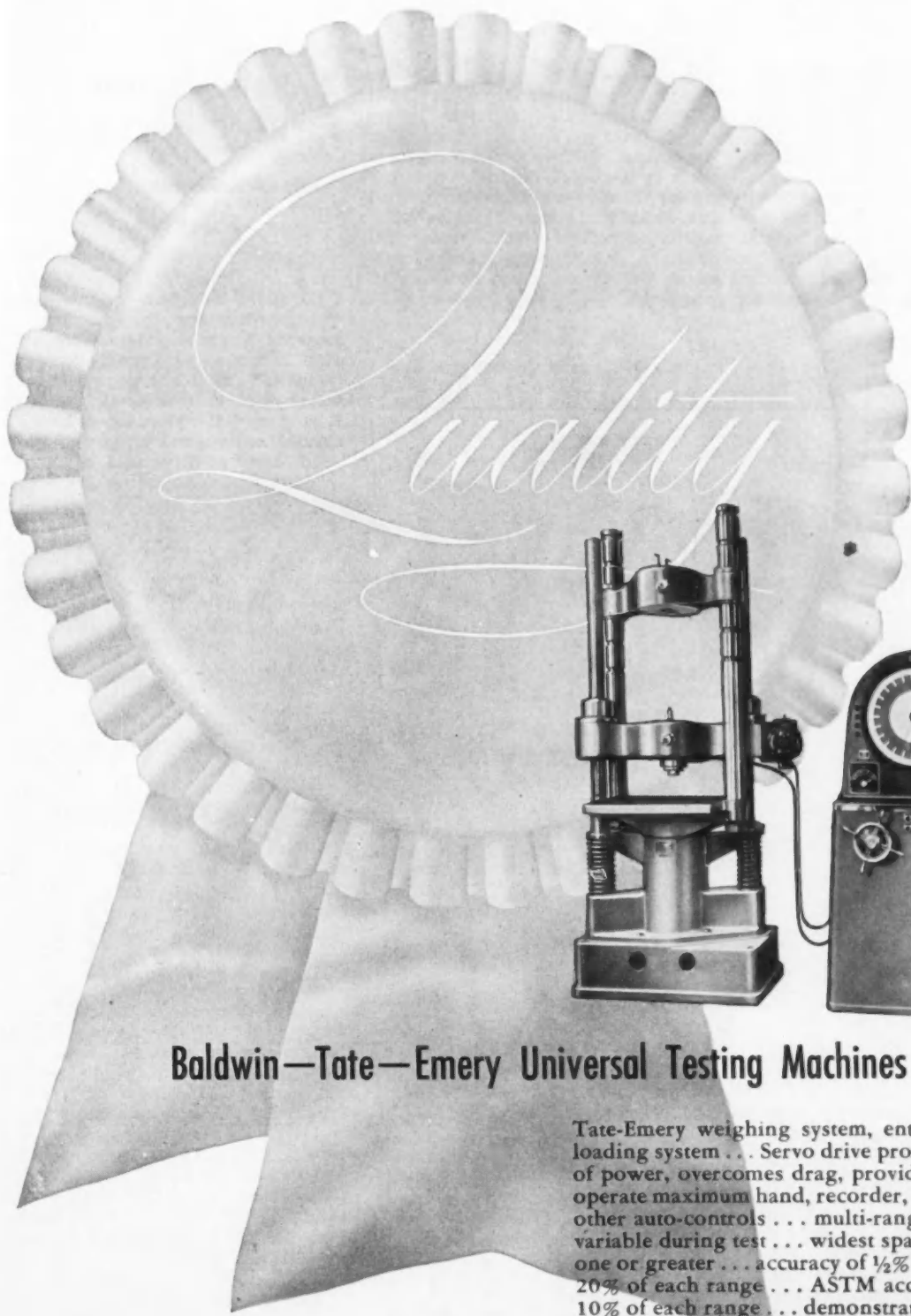
FUTURE turbojet engines are going to have better specific weights, improved fuel economy, and automatic controls to aid pilots. This much is indicated although secrecy shrouds research development.

Since there is a direct correlation between the thermal cycle efficiency and the pressure ratio used in the cycle, higher pressure ratios are receiving attention as one means to attain better fuel economy. This would call for additional compressor stages hence a higher manufacturing cost because of the sets of discs and blades required.

Many new engines will have a variable area exhaust nozzle. Its adoption arises from the desire to operate engine components near their maximum efficiencies and over as broad a range of thrust as possible. This type of nozzle permits more rapid acceleration.

To build lighter engines use will be made of improved stainless steel alloys such as 12% chrome alloy. Other stainless steel alloys will be used in heat-treated or cold-worked conditions

Turn to Page 110



Baldwin—Tate—Emery Universal Testing Machines

Tate-Emery weighing system, entirely separate from loading system . . . Servo drive provides outside source of power, overcomes drag, provides excess energy to operate maximum hand, recorder, load maintainer and other auto-controls . . . multi-range dial . . . selection variable during test . . . widest span of ranges—200 to one or greater . . . accuracy of $\frac{1}{2}\%$ guaranteed down to 20% of each range . . . ASTM accuracy guaranteed to 10% of each range . . . demonstrated sensitivity shows 1 pound in a million . . . zero essentially positive . . . negligible hysteresis, creep or temperature errors . . . complete calibration and maintenance service . . . installation by a qualified Baldwin field engineer.

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TESTING

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HEADQUARTERS

in order to carry higher loads. Disc-alloy is being considered for high temperature disc application while titanium offers possibilities for compressor parts. At present there is lacking experience in the manufacture and machining of titanium.

The extent to which controls are made automatic depends on tactical needs. At a minimum the variable area exhaust nozzle will undoubtedly be controlled automatically to provide

rapid acceleration and to schedule operation at minimum fuel consumption.

This paper also discusses general design problems met in planning the J34 engine. (Paper "Design Considerations in Turbojet Engines," was presented at SAE Detroit Section Meeting, Feb. 6, 1950. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

Aircooled Engines For Civil Transport?

Based on paper by

ROBERT INSLEY

Continental Aviation & Engineering Corp.

SIX basic aircooled engine models, employing two cylinder sizes and covering a power range from 125 to 1000 hp, have successfully completed Ordnance endurance tests and service tests, with one model in production. It is proper, therefore, to consider the use of these engines for civil transport.

To arrive at some idea of the relative merits of the aircooled engine, aircooled, liquid-cooled, and diesel type engines are rated as follows:

	Order of Merit		
	AC	LC	Diesel
Minimum weight	1	2	3
Minimum specific fuel consumption	2	2	1
Minimum first cost	1	1	2
Minimum service cost	1	1	2
Minimum size	1	2	3
Maximum engine life	1	1	1
Maximum dependability	1	1	1
Min. fuel cost and maximum availability	1	1	1
Min. noise, vibration, smoke, odor	1	1	2
Minimum fire hazard	2	2	1

This tabulation was not contrived to provide a final score in the comparison of engine types. The relative importance of the items is too indistinct to make this possible. But it is to be noted that regardless of the relative weights, the high and low numbers are fairly evenly distributed, and giving credit to the low rather than the high score the totals are: aircooled 12, liquid cooled 14, diesel 17. (Paper "Recent Advances in Gasoline Engines for Transport," was presented at SAE National West Coast Meeting, Los Angeles, Aug. 14, 1950. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

Reduced-Scale Models Are Money Savers

Based on paper by

R. A. BECKWITH

Koehring Co.

DESIGNERS of heavy equipment can often save money and time by making a reduced-scale model prior to con-



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VULCAN fabrics over 20 other materials tested.

VULCAN fabrics resist oil, gasoline, alcohols, butane, propane, aromatics, solvents and acids commonly encountered in automotive operation.

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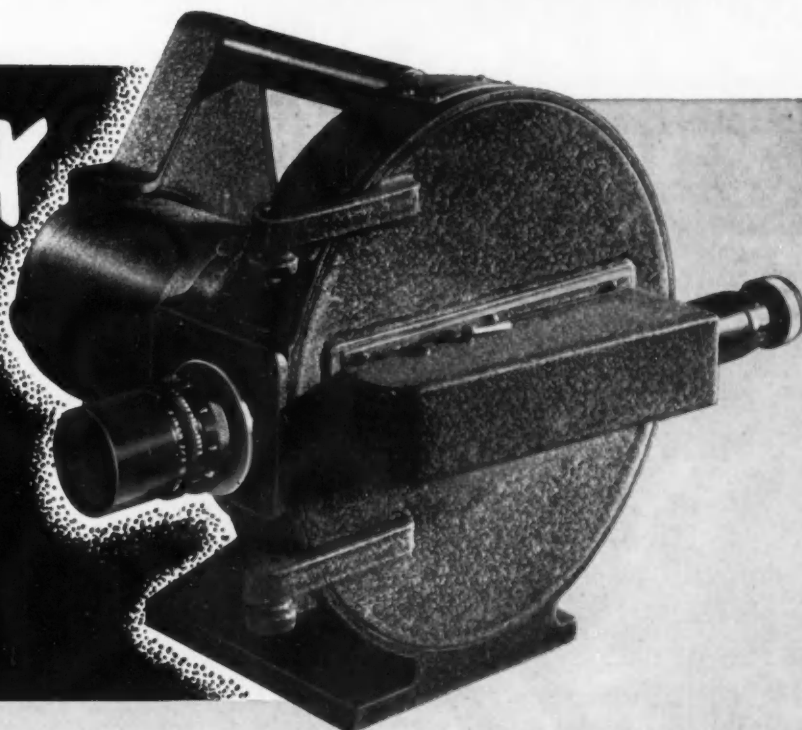
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structing a full-scale working model. Here are some of the reasons why:

Management and members of the sales department can get a better insight into the problems involved when they see a model rather than drawings and having done so, offer suggestions of a non-engineering type, as for example, matters of appearance.

Contractors will be better able to judge accessibility for maintenance.

Problems not clearly understood by

the non-technical mind can be comprehended better by visual study.

Group discussions are shortened when held around a table displaying a reduced-scale model.

Linkages, styling and arrangement of units, accessibility, procedure of assembly, and analysis of operating stresses can be tackled better than when drawings are used.

The story of the finished machine can be told in advance of construction

in service educational programs and sales promotional work.

Communication between the practiced and unpracticed engineer is facilitated; there is more eye-to-eye seeing and less chance of misunderstanding.

Models Can Be Economical

Drawing board work can be saved because possible inferences can be caught more quickly.

If proper equipment and personnel are employed to build the models the cost need not be high. The modern Do-all saw is especially suited to this kind of work. Many testing laboratories are now doing stress analysis using reduced-scale models in steel of parts which are used to make up the operating assemblies of total machines. Testing arrangements are made so that unit stress from secondary loadings as well as loads from irregular operation can be detected. For this work both brittle coatings and wire resistance strain gauges are used.

(Paper "Use of Reduced-Scale Models in Heavy-Duty Equipment Design," was presented at SAE National Tractor Meeting, Milwaukee, Sept. 12, 1950. It is available in full multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

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T-TYPE Clutch Release BEARINGS

WITH THE... THAT TAMES TROUBLE

Function of Additives In Heavy Duty Oils

Based on paper by

J. M. MILLER

Standard Oil Co. (Indiana)

THE classical definition of detergency as "cleansing ability" is inadequate to describe the functions of detergent additives in heavy duty motor oils. It might better be defined as the property of an oil which assists in preventing (not removing) the accumulation of dirt on engine parts. Detergency should not be confused with solvency wherein undesirable contaminants are dissolved, because the former is largely a colloidal phenomenon whereby the contaminants are held in suspension in the oil. The mechanism of detergency in oils is believed to be both physical and chemical.

Oxidation inhibitors serve three functions in oils. The most important function is to deactivate the metals of construction, particularly copper and iron, which act as catalysts to the ox-

Turn to Page 114

Design with Chain. Specify **LINK-BELT**

The obvious advantages of chain for driving accessories on gasoline and Diesel Engines are further heightened by selecting Link-Belt Chain Drives.

By reason of vast experience and unsurpassed facilities, Link-Belt chain specialists can be of exceptional assistance to designers and builders of all types of internal combustion engines.

Exclusive features of Link-Belt chain drives give smooth, efficient service throughout the life of the drive.

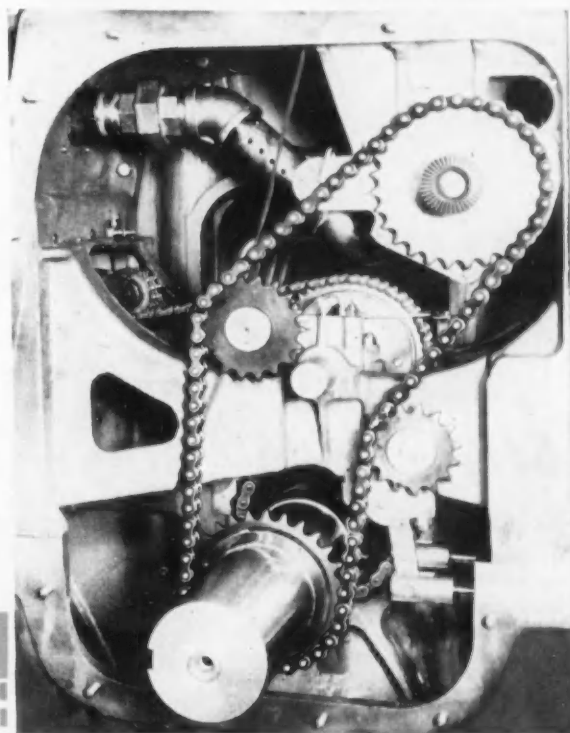
Consult Link-Belt on any phase of engine design as influenced by use of chain drives and especially, ask us about a test drive for your new model engines.

WHY CHAIN DRIVE?

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Easy to apply, install, lubricate.

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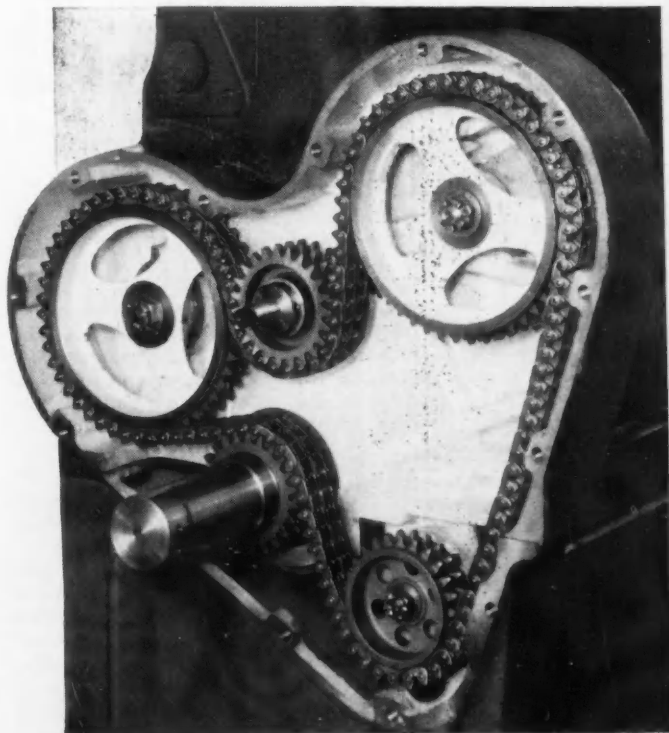
LINK-BELT COMPANY

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Johannesburg. Offices in Principal Cities.

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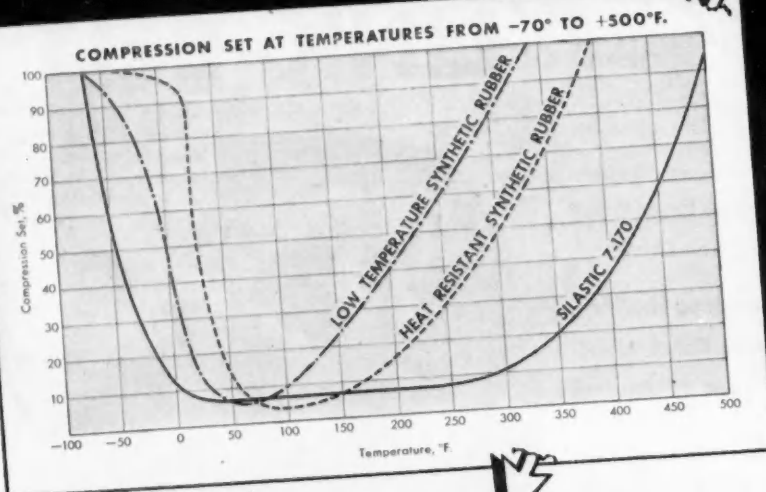


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Link-Belt Duplex Silverstreak Silent Chain for timing and for fuel pump drive of Sheppard Model 12 Diesel Engine.

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Combine that kind of elastic memory with excellent resistance to aging, to oxidation and to attack by a variety of chemicals and hot oils, and you have Silastic—the most stable of all resilient gasketing materials. That's why design engineers and maintenance men specify Silastic, the Dow Corning Silicone rubber that pays for itself many times over in reduced maintenance costs and improved performance.

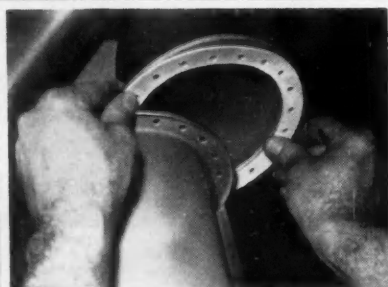


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In aircraft cabin heating and pressurizing systems, Silastic gaskets stay elastic under operating temperatures ranging from -70° to 400°F. Similarly, Silastic gaskets and O-rings withstand hot oils at about 450°F. in automotive, aircraft, diesel-electric engines.

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dation process. Another important function is to react with and chemically change or destroy the initial oxidation products of oil to prevent the sequence of oxidation steps from forming asphaltic and resinous by-products. The third function is to form a protective film on those bearing metals susceptible to corrosion by the organic acids resulting from oil oxidation.

Variations Among Additives

Lubricating-oil additives differ greatly in ability to cope with deposits from fuel. Non-detergent additives, for the most part, are completely ineffective, while additives imparting detergent-dispersant characteristics vary greatly in the effects they produce. Some reduce deposits from fuel; others aggravate deposition.

The paper also traces the history of additive oils and outlines Army engine tests leading to the 2-104 and 2-104B specifications. (Paper "Why Heavy Duty Motor Oils?" was presented at SAE Central Illinois Section Meeting, Peoria, June 12, 1950. It is available in full multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

What Price High Additive Lubricants?

Based on paper by

HANS M. GADEBUSCH

General Motors Corp.

THIS paper poses the question: what are the engine demands on a good crankcase lubricant and how can they be met?

It lists these demands as lubricity, heat resistance, low carbon formation, and non-sludging behavior, covering each in turn. It then proceeds to a detailed discussion of low additive and high additive content lubricants.

Additive Effect Evaluated

Raising the question as to how much more additive is desirable, examination is made of high additive content versus fuel quality, engine life, and oil life. (Paper "High Additive Content Motor Oils Versus Fuel Quality and Engine Life," was presented at SAE National West Coast Meeting, Los Angeles, Aug. 14, 1950. This paper is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to non-members.)

Lull Traveloader

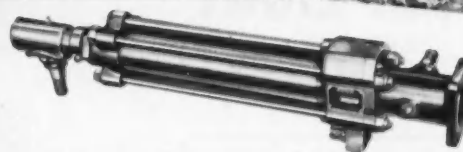


Lull Shovel loader

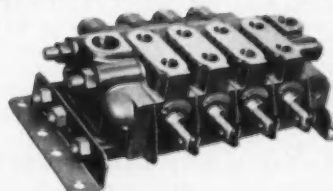


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New Members Qualified

These applicants qualified for admission to the Society between Sept. 10, 1950 and Oct. 10, 1950. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

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Robert Edwin Williams (A).

Buffalo Section

Richard Lanier Hunt (J), Robert William Loyd, Jr. (M), Albert L. Miller (A).

Canadian Section

Edwin Alfred Backlund (J), Wallace Gordon Brown (A), Arthur Ellis Cooke (M), George Galloway (A), Ian Malcolm Hamer (M), L. Thomas E. Hill (A), Alban A. Larkin (A), Robert Nor-

man Lindley (M), John Tennant Pank (A), W. G. Pascoe (A), Duncan Cameron Quin (A), John Charles Tew (A).

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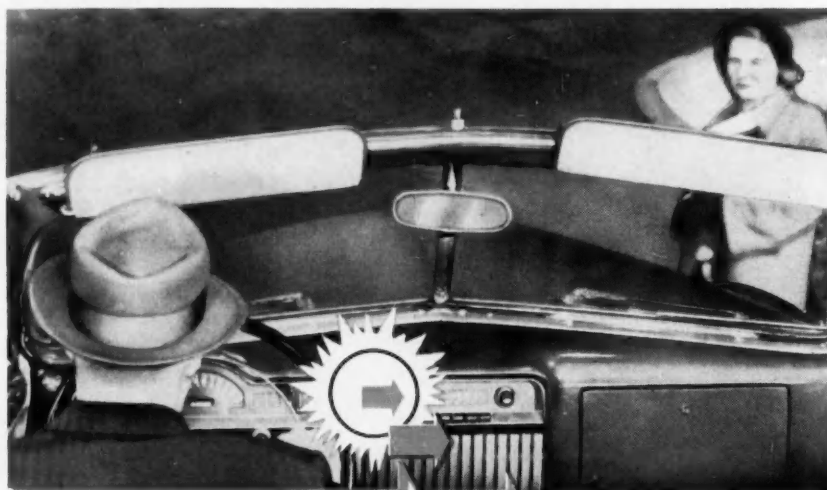
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Illuminated direction signals for motor vehicles are fast approaching the "standard equipment" classification of safety glass and sealed beam headlights. As the use of lights for this and other signaling purposes becomes universal, TUNG-SOL Flashers assume greater importance as part of any automotive system.

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Though it normally lasts for the life of the vehicle, the TUNG-SOL Flasher requires no maintenance and consumes little current. Since 1939, nearly 10,000,000 have been bought. The TUNG-SOL Flasher is now standard or optional equipment on virtually every American made automobile. Write for more information about TUNG-SOL Flashers. TUNG-SOL LAMP WORKS INC., Newark 4, N. J. Sales Offices: Atlanta, Chicago, Dallas, Denver, Detroit, Los Angeles, Newark, Philadelphia.



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Mr. Parks had a tubing problem...

so he called in the ELECTRUNITE Metallurgist...



and in practically no time at all...



Mr. Parks manufactures school desks. Very good desks, too . . . but, even so, Mr. Parks is always looking for ways to make them better.



This is the way Mr. Parks' problem came about . . . 1½" x 11 gauge tubing is bent U shape to form a support for both seat and table of Mr. Parks' desks. Design calls for a short radius bend, and he was using a fully normalized tube that Rockwell "B" tested under 55.

"Not stiff enough", decided Mr. Parks. "No desk of mine is going to sag when a heavyweight leans against it! On the other hand, the tube must not be so hard it breaks in bending." What to do? — one thing, of course, and Mr. Parks did it. He called in the ELECTRUNITE Tubing Metallurgist. As a result of this call, processing changes were made resulting in a stiffer tube with a higher yield point

and a higher Rockwell reading. These tubes readily take the short radius bend and still give Mr. Parks' desks the extra sturdiness and strength he wanted them to have.

Mr. Parks isn't his real name, of course, but his problem was real. When you have a tubing problem, why not do as Mr. Parks did? Call for a Republic ELECTRUNITE Tubing Metallurgist. There is no charge for his services and no obligation on your part for his help. Just let us know when you would like to see him—and he'll be there.

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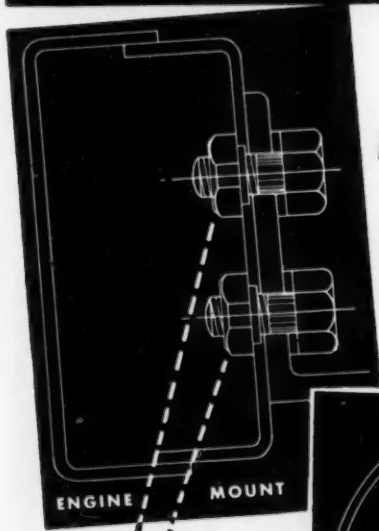
Republic
ELECTRUNITE TUBING



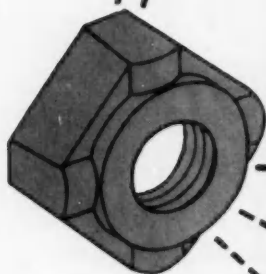
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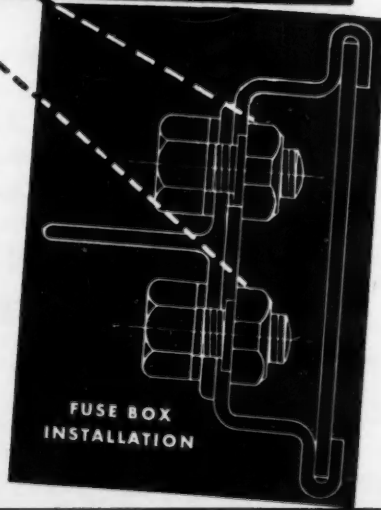
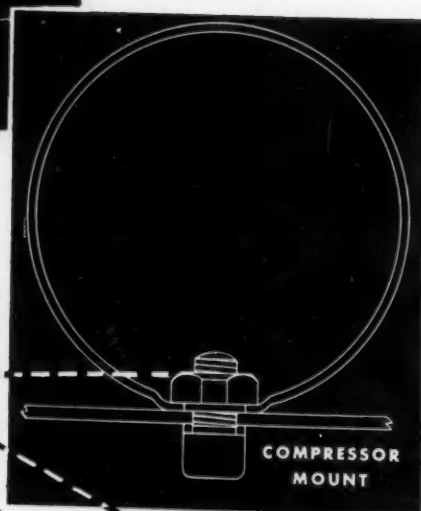
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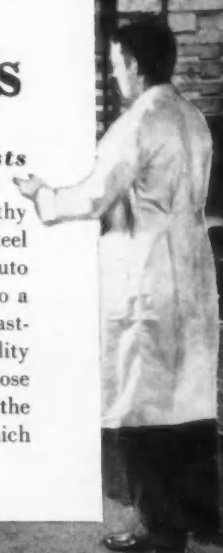
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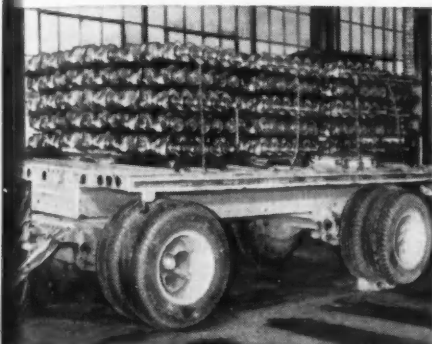
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... and helps lower crankshaft costs

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Progress Report No. 2 on the Application of Mass-Produced Cast Alloy Steel Crankshafts to the solution of some of today's Engine Production Problems.



CHEMICAL COMPOSITION:					
	C	Mn	Si	Cr	
Minimum	1.30	.85	.65		
Maximum	1.40	1.00	.80	.10	
	Cu	Ni	Mo	P	S
Minimum		.45	.13		
Maximum	.10	.55	.18	.08	.08

By a special molding process, stacks of slab cores are arranged to cast 4 crankshafts at one time. Equally unique are—the special chemistry of AUSCO 80, the electric-furnace melting, the foundry techniques, and heat straightening—resulting in Cast Alloy Steel Crankshafts of highest quality, that actually cost less!

To give positive proof of freedom from injurious defects, Ausco Cast Alloy Steel Crankshafts are X-Ray Photographed under a million-volt camera. This is only one of a long series of inspections and tests that these crankshafts must undergo to insure the superior strength and wear resistance which they are so ably demonstrating in daily service all over this country in mass-produced motor cars.

A 100-page book of evidence of the advantages of Cast Alloy Steel Crankshafts for mass-produced motor cars is available to engineers and executives on request.

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Elimination of rough cheeking operation, has reduced machining at least 75%.

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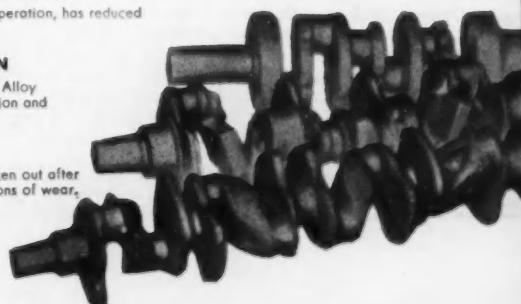
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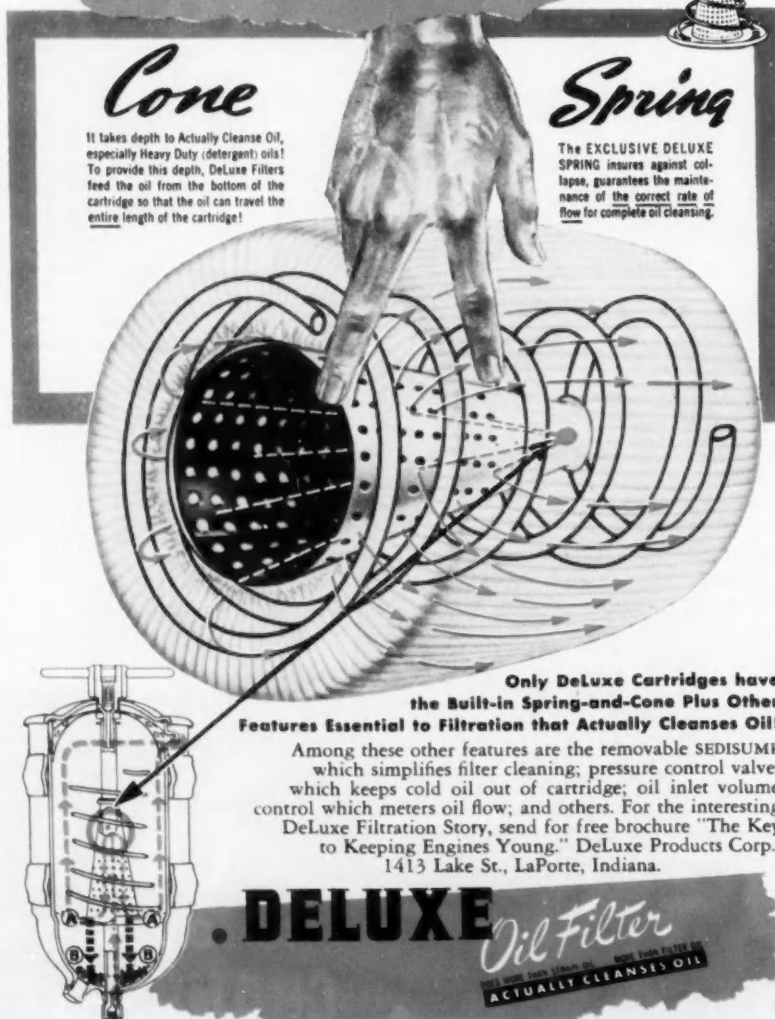
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Engineering News

No. 5



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Practically every application presents a different set of problems. Hence, Stackpole engineers welcome full details of your requirement on which their recommendations and sample seals or washers can be based. You be the judge!



GET THIS HELPFUL CARBON-GRAPHITE SPECIALTIES BOOKLET

This 44-page, profusely illustrated book has been prepared to help you evaluate the possibilities of components of molded carbon, graphite and powdered metal composition in a broad range of modern equipment. Included are details on Stackpole tube anodes, battery carbons, ground rods, contacts, carbon piles, chemical carbons, friction segments, clutch rings, brazing and welding carbons, carbon molds and dies and many other products.



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If you have a possible application, why not submit details to Stackpole for recommendation?

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Turn to Page 124



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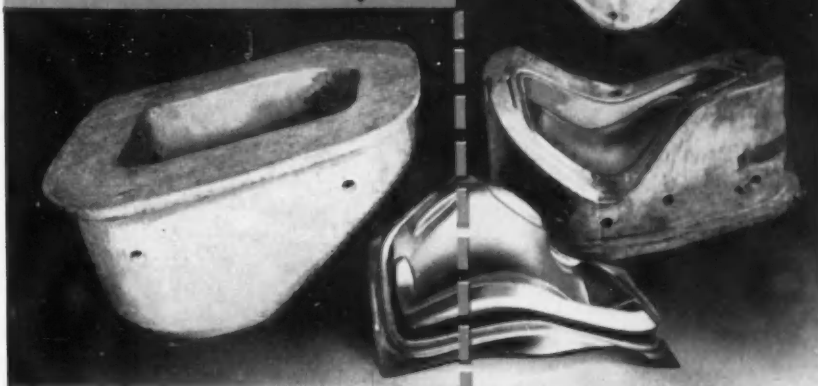
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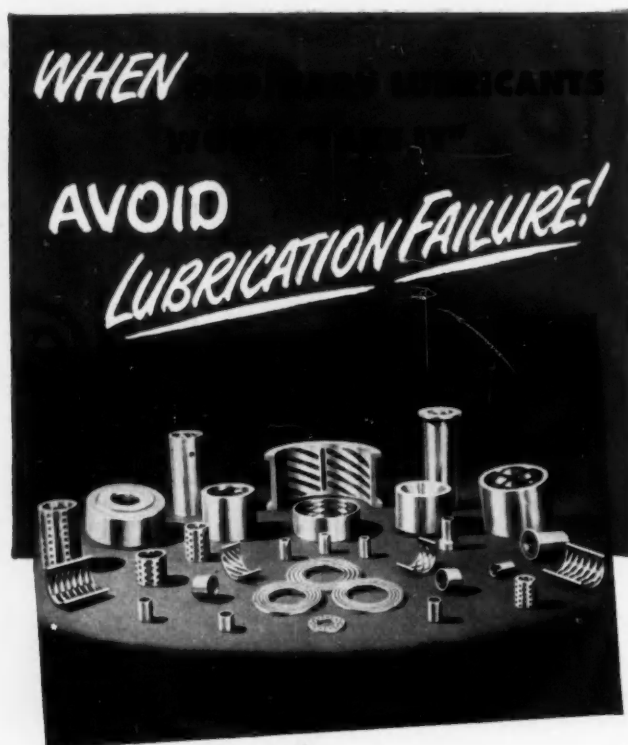


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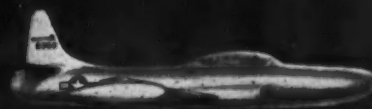
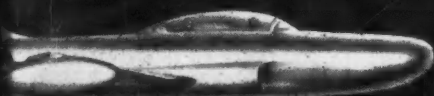
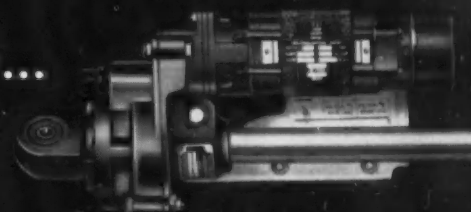
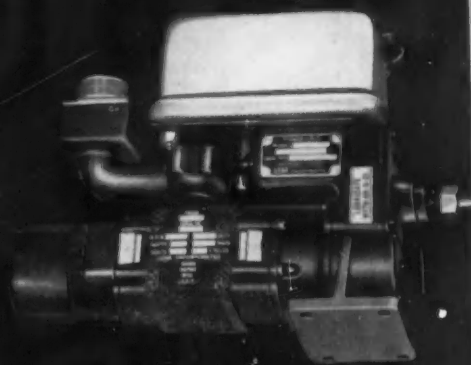
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to actuate wing flaps,

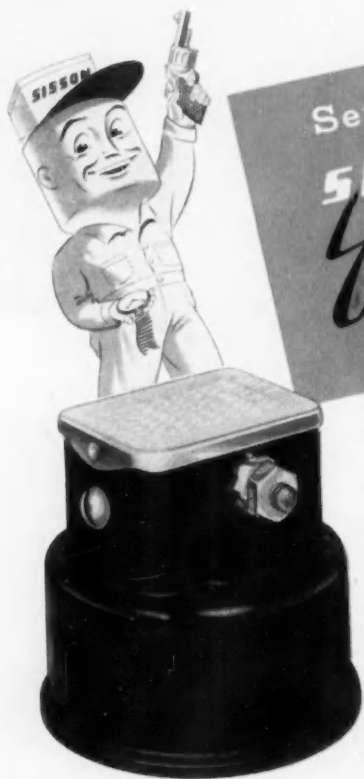
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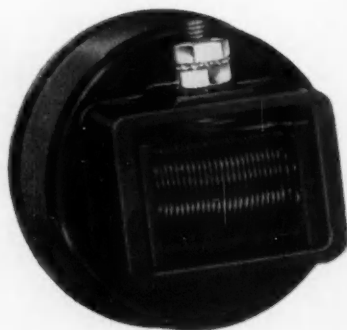
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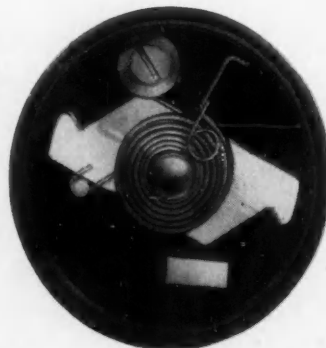
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For the Sake of Argument

Cooperation

By Norman G. Shidle

No word means more different things than "cooperation." An act which the doer sees as help, the receiver may brand as interference—or nosiness. Too often we define cooperation as "working together" and let it go at that.

True definition is "working together for a common end." The important words are "for a common end." Most of the friction in cooperative work comes from fuzziness about objectives. Unless objectives are joint, cooperation (by definition) is impossible.

Committee work proves this point over and over. Hundreds of manhours have been wasted by men, working together in all good will and friendliness, who failed to define scope and aims at the start. A group rarely gets where it wants to go when it talks routes and time tables before destination.

But committees are more or less formal bodies. Simply by putting first things first, they can lay the ground for successful cooperation. Individuals on everyday tasks have more trouble. The consequence of the specific project rarely warrants formalized aim-stating. We'd get little done if we stopped to confer about aims every time someone said: "Give me a hand with this, please" or "Can I help you?"

So, everyday cooperation often means acceptance by the giver of the receiver's aim. It consists mostly of one person helping another to achieve his already determined end. Unless the giver accepts that aim, cooperation doesn't take place—only a working together.

Working alongside someone without friction is not necessarily cooperation, either. A neighbor saw little Johnny in his yard and asked: "Where is your sister, Johnny?" Johnny replied: "Oh, she's inside playing a duet. I finished first." . . . His sister's aim was to play a duet; Johnny's was to get through playing a duet.

So rarely can specific ends of two or more people be identical that full cooperation remains an uncommon achievement. Understanding its true nature is the first step in making it more frequent.

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